ERDC/GSL TR-19-52

Geotechnical and Structures Laboratory

US Army Corps
of Engineers®
Engineer Research and
Development Center

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

Laboratory Characterization of Alkali-Silica Reaction Susceptibility of Aggregates for Charleroi Lock and Dam, Monongahela River Project

Monica A. Ramsey

December 2019

The U.S. Army Engineer Research and Development Center (ERDC) solves the nation's toughest engineering and environmental challenges. ERDC develops innovative solutions in civil and military engineering, geospatial sciences, water resources, and environmental sciences for the Army, the Department of Defense, civilian agencies, and our nation's public good. Find out more at www.erdc.usace.army.mil.

To search for other technical reports published by ERDC, visit the ERDC online library at http://acwc.sdp.sirsi.net/client/default.

ERDC/GSL TR-19-52
December 2019

Laboratory Characterization of Alkali-Silica Reaction Susceptibility of Aggregates for Charleroi Lock and Dam, Monongahela River Project

Monica A. Ramsey

Geotechnical and Structures Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

Prepared for U.S. Army Corps of Engineers Pittsburgh District
Pittsburgh, PA 15222

Under MIPR W81ET491842462, Lower Monongahela River Navigation System Feasibility Study

Abstract

The purpose of this study was to identify potential alkali-aggregate reactivity of local aggregates provided by the Pittsburgh District according to ASTM C1260 and to investigate the effectiveness of a combination of cementitious materials and aggregates from provided mixture designs in suppressing alkali-silica reactivity (ASR) induced expansions according to the ASTM C1567. Three ASTM C1260 tests were performed for each aggregate (Hanson, Georgetown, and Shelly). A total of 48 ASTM C1567 tests were performed from the combination of the four mix designs, four fly ash sources, and three aggregate sources. The limiting criteria for the proposed materials and mix designs was expansions less than 0.08% at 30 days of testing in accordance to the Unified Facilities Guide Specification (UFGS) Division 03 Concrete Section 03 30 00.50. Based on this specification, the tested aggregates are considered potentially reactive with 30-day mortar bar expansions of 0.1970% for Hanson, 0.1683% for Georgetown, and 0.1623% for Shelly. However, all 48 combinations of the ASTM C1567 tests passed the limiting criteria with 30-day expansions less than 0.08%. These results indicate that the constituent project materials in the proposed mix designs can effectively mitigate ASR.

Contents

Figures and Tables

Figures

Tables

Preface

This study was conducted by U.S. Army Engineer Research and Development Center (ERDC) for the Corps of Engineers Pittsburgh District in Pittsburgh, PA, for Charleroi Lock Reconstruction project under MIPR W81ET491842462. The Pittsburgh District technical manager was Mr. Glenn W. Bush Jr.

The work was performed by the Concrete and Materials Branch (GMC) of the Engineering Systems and Materials Division (GM), U.S. Army Engineer Research and Development Center, Geotechnical and Structures Laboratory (ERDC-GSL). At the time of publication, Mr. Christopher M. Moore was GMC Chief; Mr. Justin S. Strickler was GM Chief; and Mr. R. Nicholas Boone was the Technical Director for Force Projection and Maneuver Support. The Deputy Director of ERDC GSL was Mr. Charles W. Ertle II, and the Director was Mr. Bartley P. Durst.

COL Teresa A. Schlosser was the Commander of ERDC, and Dr. David W. Pittman was the Director.

1 Introduction

1.1 Background

The baseline design for the Charleroi Locks originated in 1991 from the Lower Monongahela River Navigation System Feasibility Study. The feasibility study evaluated the ability of Locks and Dams 2, 3, and 4 of the Monongahela River Navigation System to serve navigation interests through the year 2050. The conclusion of the study was to implement a "2 for 3" replacement known as "The Lower Mon Project."

The Lower Mon Project consists of replacement of the fixed-crest dam at Locks and Dam 2 with a gated dam to be renamed the Braddock Locks and Dam, construction of twin 84-ft by 720-ft locks at Locks and Dam 4 to be renamed the Charleroi Locks and Dam, removal of Locks and Dam 3 at Elizabeth, navigation dredging, and relocation of adversely impacted public facilities. The combination of these features will allow for one navigation pool between Braddock Locks and Dam and the Charleroi Locks and Dam, i.e., a 30.3-mile pool.

The Charleroi Lock reconstruction began in 2002 with site development and has continued as funding has become available for separate contracts for the construction of the river wall, upper and lower guide walls, emptying basin, middle wall monoliths M22-M27, and river chamber completion. The project uses government-designed concrete mixes developed in 2005 by the U.S. Army Engineer Research Development Center (ERDC) in Vicksburg, MS, and produced at the left bank batch plant, a government-owned, contractor-operated batch plant located across the river from the lock chambers.

1.2 Problem statement

Alkali-silica reaction (ASR) is a chemical reaction between alkali hydroxides in concrete and active minerals in aggregates that can cause serious expansion and cracking in concrete. The premature distress can result in loss in serviceability in structures such as locks and dams. It is generally recognized that the use of a sufficient quantity of a suitable supplementary cementitious materials (SCM) is one of the more efficient preventative measures for controlling expansion.

Standard test methods to evaluate the ASR susceptibility of aggregates and potential methods to mitigate ASR were performed by ERDC in 2005. However, the material quality tests were outdated, and some original source suppliers of fly ash were no longer available. To ensure all local materials met the quality requirements of the Lower Mon Project specifications, the Pittsburgh District re-commissioned the materials testing for validation.

1.3 Objective and scope

The principal objective of the testing was to determine the potential reactivity of three aggregates and the effectiveness in suppressing ASR-induced expansion using a combination of SCMs in mixture designs provided by the District. Such materials include class F fly ash, silica fume, and ground-granulated blast furnace slag. Testing was performed in accordance to ASTM C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method), and ASTM C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method). A total of 48 tests were performed using the combination of mix designs, aggregates, and fly ash sources summarized in Table 1. The purpose was to ensure that the mixture design adequately mitigated expansions due to ASR in all possible combinations.

Table 1. Summary of mix designs, aggregate sources, and fly ash sources used in combination for ASR testing.

Mix Design	Aggregate Source	Fly Ash Source
Mix 1	Hanson CA	Sammis
Mix 5	Georgetown FA	Ft. Martin
Mix 7	Shelly FA	Longview
Mix 10		Brandon Shores

2 Materials

The materials listed in Table 2 were provided by the USACE-Pittsburgh District for testing described in this report. ERDC tested all materials in accordance to the ASTM requirement reference in the table for validation prior to ASR testing. Results are provided in Appendix A.

Table 2. Summary of materials used in ASR testing.

Material	Manufacturer	Location	CMB #	Testing Validation
Type II(MH) Cement	Armstrong	Cabot, PA	150063	ASTM C150
Class F Fly Ash	Headwaters Resources, Ft. Martin	Maidsville, WV	150064	ASTM C618
	Headwaters Resources, W. H. Sammis	Stratton, OH	150065	
	Separation Technologies, Longview	Maidsville, WV	180005	
	Separation Technologies, Brandon Shores	Curtis Bay, MD	180018	
Slag Cement, Grade 100	Argos-Essroc-Lehigh	Middlebranch, OH	150066	ASTM C989
Limestone Powder	Graymont	Bellefonte, PA	150067	ASTM D242
Silica Fume	Elkem Materials	Pittsburgh, PA	150068	ASTM C1240
Coarse Aggregate	Hanson	Connellsville, PA	150070	ASTM C40 ASTM C88 ASTM C117 ASTM C127/128 ASTM C131 ASTM C136
Fine Aggregate	Georgetown	Georgetown, PA	150069	
	Shelly	Reedsville, OH	160004	
AEA-92 Admixture	Euclid	Cleveland, OH	150073	ASTM C494
RET 75 Admixture			150074	
WR Admixture			150075	
AW Admixture			150076	
HRWR Admixture37			150077	

3 Experimental Program

Expansion-based measurements of ASR damage are by far the most common test methods used to assess the ASR susceptibility of aggregates. The potential reactivity of the three project aggregates (Hanson, Georgetown, and Shelly) was determined according to the ASTM C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).

In a similar test, the efficiency of suppressing ASR-induced expansion using a combination of SCM's was determined according to the ASTM C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method). The combination of SCMs was based on the composition of the four concrete mixture proportions, i.e., Mix 1, 5, 7, and 10, provided in Table 3 as outlined in the Charleroi project specifications.

The ASTM C1567 test method was developed for a single aggregate source in mortar of standard proportions and currently does not have a method for testing a combination of fine and coarse aggregates as specified in the actual concrete mixture design. To overcome the fixed concrete mixture designs, all three aggregate source materials were tested independently with each fly ash source. A total of 48 tests were performed from the combination of the four mix designs (Mix 1, 5, 7, and 10), four fly ash sources (Sammis, Fort Martin, Longview, and Brandon Shores), and three aggregate sources (Hanson, Georgetown, and Shelly).

Table 3. Concrete mixture proportions for Charleroi L&D.

Material	Mix 1	Mix 5	Mix 7	Mix 10
	Batch Quantities (lb/yd³)			
Cement (lb/yd)	167	191	253	495
Class F Fly Ash (lb/yd)	158	75	139	165
Slag Cement (lb/yd)	367	87	69	0
Silica Fume (lb/yd)	29	0	0	0
Limestone Powder (lb/yd)	155	0	0	0
¾ in. Coarse Aggregate (lb/yd)	1,323	739	1,129	1,720
1 ½ in. Coarse Aggregate (lb/yd)	0	747	935	0
3 in. Coarse Aggregate (lb/yd)	0	1,000	0	0
Fine Aggregate (lb/yd)	1,409	958	1,141	1,239
Potable Water (lb/yd)	303	183	213	258
Air Entraining Admixture (AEA) (fl oz/yd)	0	8	16	7
Water Reducing Admixture (WRA) (fl oz/yd)	0	0	0	0
High Range Water Reducing Admixture (HRWRA) (fl oz/yd)	138.1	0	0	12
Retarding Admixture (RET) (fl oz/yd)	30.1	7	7	7
Anti-Washout Admixture (AWA) (oz/yd)	97.2	0	0	0

Material quantities were proportioned to yield four 1-in. by 1-in. by 11.25-in. mortar specimens, which is one more than the minimum required. Each batch consisted of 587 g of cement or cementitious materials and 1,350 g of aggregate processed to the gradations shown in Table 4. All mortars were prepared with the water-to-cementitious materials ratio maintained at 0.47 by mass. Actual ASTM C1567 batch proportions scaled from the concrete mix designs previously discussed are detailed in Table 5. Due to prolonged setting time, all retarder was removed from the mixture proportion, and test specimens were moist cured 48 hr (opposed to the standard 24-hr moist cure) before demolding.

Table 4. Aggregate gradation for testing by ASTM C1260/C1567.

Retained on Sieve	Mass %
No. 8	10
No. 16	25
No. 30	25
No. 50	25
No. 100	15

Table 5. Batch proportions used to prepare mortar bars for ASTM C1567.

Material	Mix 1	Mix 5	Mix 7	Mix 10
	Mass (g)			
Type II(MH) Cement	136	318	322	440
Class F Fly Ash	129	125	177	0
Slag Cement	299	144	88	147
Silica Fume	23	0	0	0
Limestone Powder	126	0	0	0
Admixture	Volume (mL)			
Air Entraining Admixture (AEA)	0	0.87	1.33	0.41
Water Reducing Admixture (WRA)	0	0	0	0.70
High Range Water Reducing Admixture (HRWRA)	5.68	0	0	0
Retarding Admixture (RET)	0	0	0	0
Anti-Washout Admixture (AWA)	5.16	0	0	0

The mortar mixes were prepared in 4 min in accordance with ASTM C305 using a 71-L capacity Hobart planetary mixer with a clearance of 5.1 mm between the lower end of the paddle and the bottom of the bowl. First, the water was added to the bowl, then each admixture was added into the water using a pipette accurate to 1.0 μm. The liquids were then mixed on

low until homogeneous. Then, the blended dry cementitious materials were introduced and mixed for 30 sec on low. Next, the test aggregate was slowly added and mixed for 30 sec. The mixer was then changed to medium speed and mixed an additional 30 sec. The mixer was stopped, then the mixture was scraped with a spatula for 15 sec, taking care to mix the bottom of the mortar. This was then allowed to sit for 90 sec with the cover in place. Finally, the cover was removed, and the mortar was mixed for 60 sec at medium speed. All molds were filled by compacting the mixture with a tamper within 2 min and 15 sec after completion of the mixing. The mortar test specimens were stored in a 23°C moist cabinet for 48 hr before demolding and making the initial length measurements.

The test specimens were then immersed in sealed plastic containers filled with tap water maintained in a water bath at 80°C for 24 hr. The zero-length measurement was then taken, and the specimens were transferred in containers filled with a 1-N NaOH solution at 80°C maintained in a water bath at 80°C to accelerate expansion. Expansion measurements were made using a length comparator accurate to 1.0 μm at 3, 5, 7, 14, 21, 28, and 30 days, which is more than twice as long as the standard test duration. The average length change of the four bars is expressed as a percentage of the original effective length.

The measurements at 21, 28, and 30 days are a modification to the ASTM procedure requested by the Pittsburgh District. This modification is to ensure potential aggregate expansion is measured, as some local aggregates have historically been slow to react within the standard 14-day testing time frame.

4 Results and Discussion

All mixing and testing presented in this study closely followed the procedures specified in ASTM C1260 and ASTM C1567. The pass/fail limiting criteria for the tests conducted in this report are based on the specifications given in the Unified Facilities Guide Specification (UFGS) Division 03 Concrete Section 03 30 00.50 aggregate quality requirement limiting criteria for ASR reactivity. The UFGS states that "final approval of the concrete constituents will be based on the requirements for each individual constituent and that the final proportioned concrete for each mix design meets the reactivity requirement of measured expansion less than 0.08 percent at 32 days after casting (30 days of testing) in accordance with ASTM C1567.

The following summary of results are based on the average expansions of a minimum of three mortar bars per mixture. Detailed test data worksheets of all ASTM C1260 and ASTM C1567 are provided in Appendices B and C, respectively.

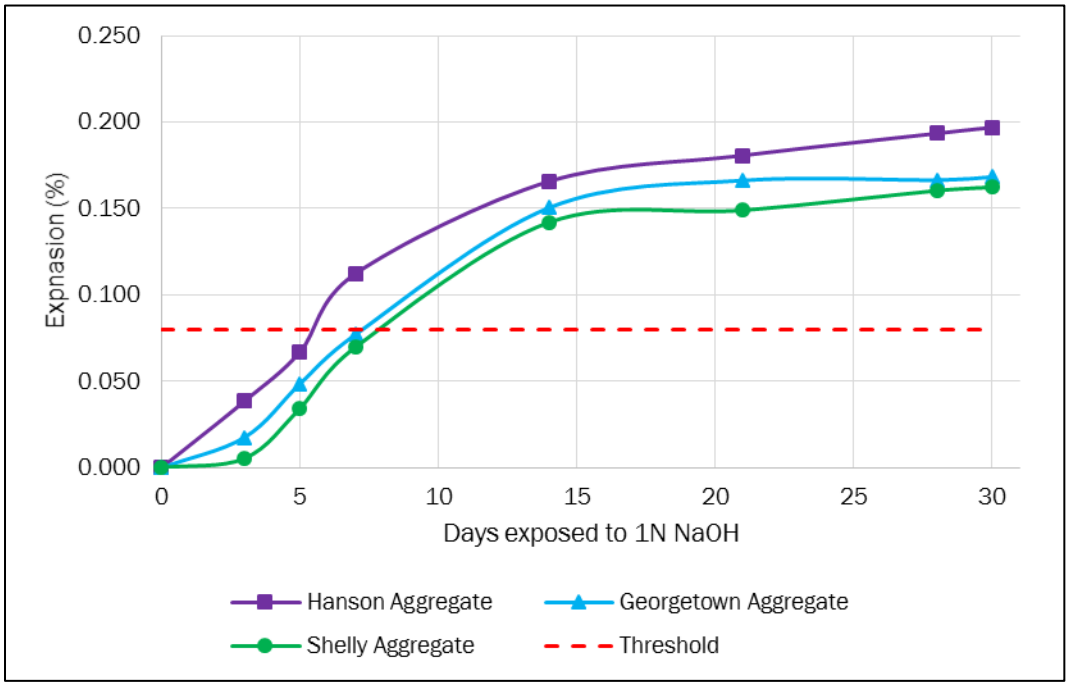
4.1 ASTM C1260

Results of the ASTM C1260 for the three test aggregates (Hanson, Shelly, and Georgetown) tested are provided in Table 6 and illustrated in Figure 1. The length change percent is an average of four mortar bars.

Table 6. Average length change percent of all project aggregates in ASTM C1260.

Age, Days	Aggregate Source		
	Hanson	Georgetown	Shelly
0	0	0	0
3	0.0385	0.0175	0.0053
5	0.0670	0.0485	0.0343
7	0.1123	0.0770	0.0697
14	0.1658	0.1505	0.1420
21	0.1808	0.1663	0.1490
28	0.1935	0.1665	0.1603
30	0.1970	0.1683	0.1623

Figure 1. Mortar bar expansions of Hanson, Georgetown, and Shelly aggregates in ASTM C1260.



Based on the project limiting criteria, i.e., expansions less than 0.08% at 30 days, all aggregates are considered potentially reactive with final 30-day mortar bar expansions of 0.1970% for Hanson, 0.1683% for Georgetown, and 0.1623% for Shelly aggregates.

4.2 ASTM C1567

Results of the ASTM C1567 test are presented in Table 7. The length change percent given is an average of four mortar bars. The average expansion at 30 days of all 48 different test mixtures fell below the 0.08% limiting criteria.

It is notable to mention that although still passing, the Hanson source aggregate resulted in higher expansions compared to the Shelly and Georgetown source aggregates. This compares with the ASTM C1260 results of the Hanson aggregate producing the highest expansions. This is possibly explained by the Hanson source being a coarse aggregate and the Shelly and Georgetown sources being fine aggregates. More preparations were required for the coarse aggregate to meet the graduation requirements, and the crushing of the material could affect the expansion.

Table 7. Results of all ASTM C1567 tests at 30 days.

Mixture ID	Aggregate Source	Fly Ash Source	Average % Expansion
Mix 1	Hanson	Sammis	0.0183
		Ft. Martin	0.0198
		Longview	0.0200
		Brandon Shores	0.0185
	Georgetown	Sammis	0.0075
		Ft. Martin	0.0075
		Longview	0.0093
		Brandon Shores	0.0090
	Shelly	Sammis	0.0090
		Ft. Martin	0.0093
		Longview	0.0073
		Brandon Shores	0.0075
Mix 5	Hanson	Sammis	0.0443
		Ft. Martin	0.0470
		Longview	0.0595
		Brandon Shores	0.0440
	Georgetown	Sammis	0.0185
		Ft. Martin	0.0170
		Longview	0.0188
		Brandon Shores	0.0198
	Shelly	Sammis	0.0160
		Ft. Martin	0.0147
		Longview	0.0208
		Brandon Shores	0.0193
Mix 7	Hanson	Sammis	0.0333
		Ft. Martin	0.0333
		Longview	0.0350
		Brandon Shores	0.0337
	Georgetown	Sammis	0.0130
		Ft. Martin	0.0168
		Longview	0.0213
		Brandon Shores	0.0195
	Shelly	Sammis	0.0130
		Ft. Martin	0.0160
		Longview	0.0223
		Brandon Shores	0.0200
Mix 10	Hanson	Sammis	0.0638
		Ft. Martin	0.0593
		Longview	0.0728
		Brandon Shores	0.0593
	Georgetown	Sammis	0.0123
		Ft. Martin	0.0130
		Longview	0.0188
		Brandon Shores	0.0148
	Shelly	Sammis	0.0135
		Ft. Martin	0.0138
		Longview	0.0167
		Brandon Shores	0.0150

4.2.1 Mix 1

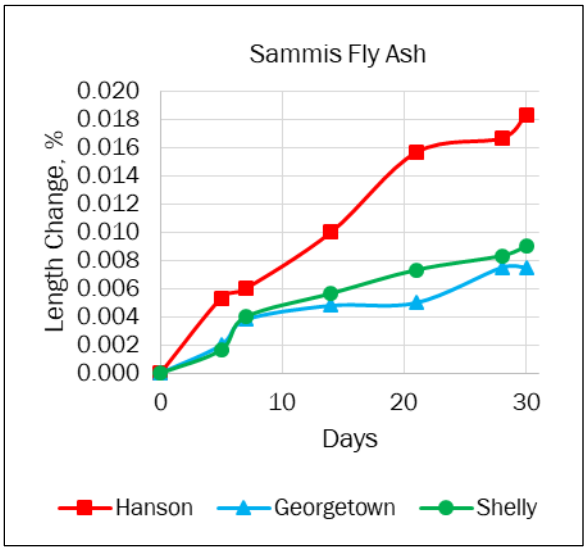
The average length change data are shown in Table 8 for all 12 combinations of materials using Mix 1. Figure 2 compares the three aggregates tested against the four fly ash sources for the Mix 1 design. The Hanson aggregate is clearly the most reactive aggregate in Mix 1 regardless of the fly ash used. The graphs illustrate similar expansions in both the Shelly and Georgetown aggregates. The largest expansion at 30 days was 0.02% from the Hanson aggregate and Longview fly ash combination. The smallest expansion at 30 days, i.e., 0.0073%, was from the Shelly aggregate and Longview fly ash combination. All 12 combinations of Mix 1 meet the project requirement of expansions less than 0.08% at 30 days.

Table 8. Average length change of mortar bars made from Mix 1 materials.

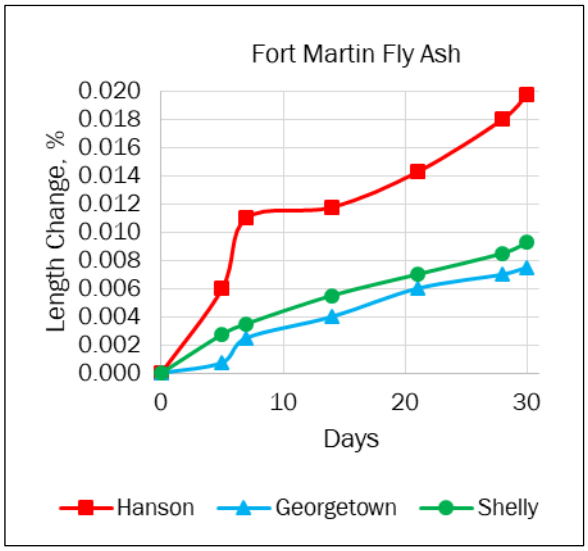
	Sammis Fly Ash			Ft. Martin Fly Ash			Longview Fly Ash			Brandon Shores Fly Ash		
Days	*H	*G	*S	*H	*G	*S	*H	*G	*S	*H	*G	*S
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0053	0.0020	0.0017	0.0060	0.0008	0.0028	0.0047	0.0023	0.0013	0.0038	0.0023	0.0013
7	0.0060	0.0038	0.0040	0.0110	0.0025	0.0035	0.0073	0.0040	0.0023	0.0090	0.0040	0.0040
14	0.0100	0.0048	0.0057	0.0118	0.0040	0.0055	0.0107	0.0060	0.0043	0.0118	0.0063	0.0055
21	0.0157	0.0050	0.0073	0.0143	0.0060	0.0070	0.0170	0.0073	0.0047	-	-	-
28	0.0167	0.0075	0.0083	0.0180	0.0070	0.0085	0.0183	0.0083	0.0063	0.0160	0.0088	0.0075
30	0.0183	0.0075	0.0090	0.0198	0.0075	0.0093	0.0200	0.0093	0.0073	0.0185	0.0090	0.0075

*Notes:
H- Hanson Aggregate
G- Georgetown Aggregate
S-Shelly Aggregate

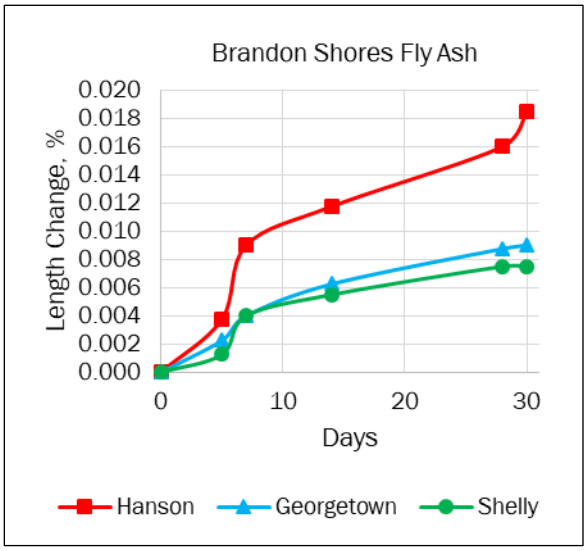
Figure 2. Mortar bar expansions versus time for Mix 1.



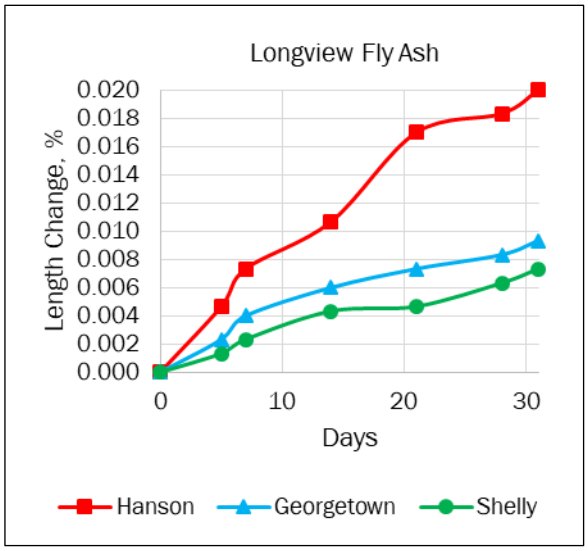
a) Sammis Fly Ash.



b) Ft. Martin Fly Ash.



c) Brandon Shores Fly Ash.



d) Longview Fly Ash.

4.2.2 Mix 5

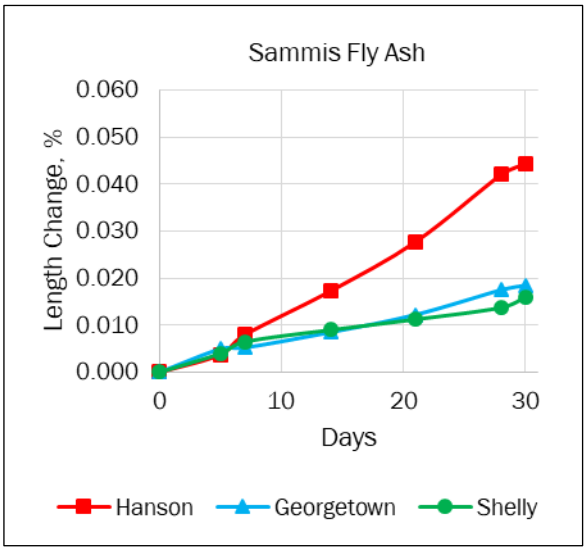
The average length change data are shown in Table 9 for all 12 combinations of materials using the Mix 5 design. Figure 3 compares the three aggregates tested against the four fly ash sources. Similar to the trends in Mix 1, the Hanson aggregate is the most reactive aggregate in Mix 5 regardless of the fly ash used. The highest 30-day length change was 0.0595% from a combination of the Longview fly ash and Hanson aggregate. The lowest 30-day length change was 0.0147% from a combination of Fort Martin fly ash source and Shelly sand.

Table 9. Average length change of mortar bars made from Mix 5 materials.

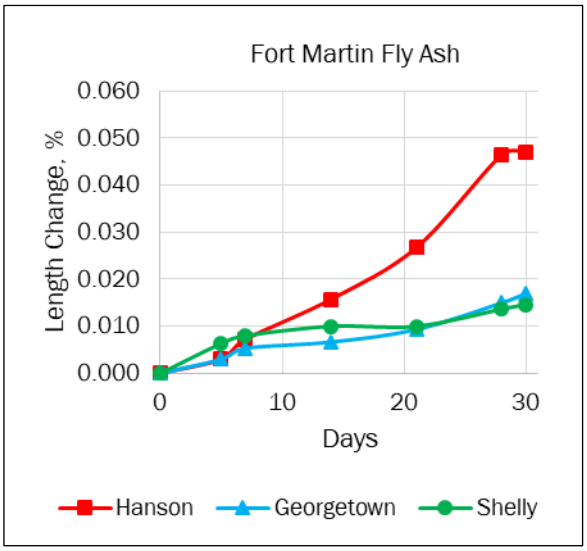
	Sammis Fly Ash			Ft. Martin Fly Ash			Longview Fly Ash			Brandon Shores Fly Ash		
Days	*H	*G	*S	*H	*G	*S	*H	*G	*S	*H	*G	*S
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	-	0.0000	-	-	-	-	0.0043	-.0013	0.0038	0.0027	0.0043	0.0018
5	0.0038	0.0050	0.0040	0.0030	0.0030	0.0063	-	-	-	0.0057	0.0070	0.0080
7	0.0080	0.0053	0.0065	0.0073	0.0053	0.0080	0.0123	0.0008	0.0035	0.0117	0.0078	0.0070
14	0.0173	0.0085	0.0090	0.0158	0.0067	0.0100	0.0170	0.0035	0.0025	0.0330	0.0125	0.0120
21	0.0278	0.0123	0.0113	0.0268	0.0093	0.0100	0.0358	0.0123	0.0105	-	-	-
28	0.0420	0.0175	0.0138	0.0465	0.0150	0.0137	0.0595	0.0173	0.0178	0.0427	0.0178	0.0170
30	0.0443	0.0185	0.016	0.0470	0.0170	0.0147	0.0595	0.0188	0.0208	0.0440	0.0198	0.0193

***Notes:**
H - Hanson Aggregate
G - Georgetown Aggregate
S - Shelly Aggregate

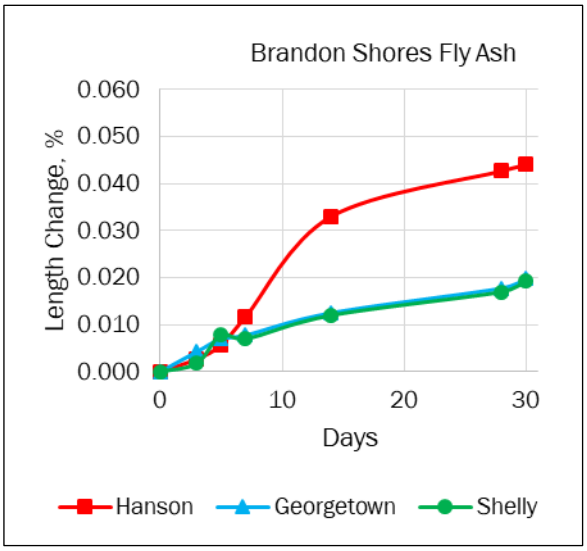
Figure 3. Mortar bar expansions versus time for Mix 5.



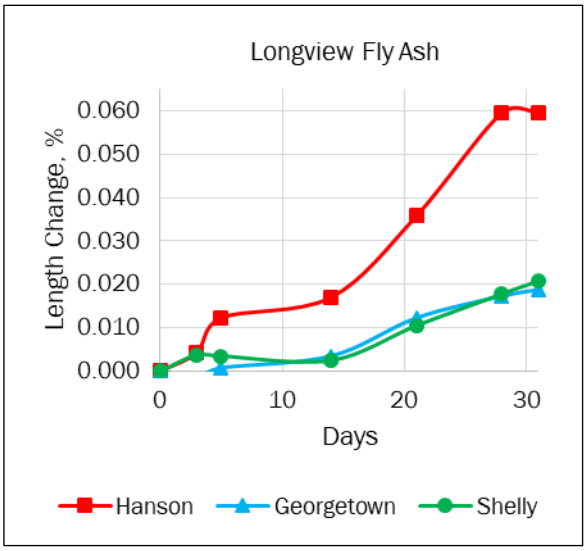
a) Sammis Fly Ash.



b) Ft. Martin Fly Ash.



c) Brandon Shores Fly Ash.



d) Longview Fly Ash.

4.2.3 Mix 7

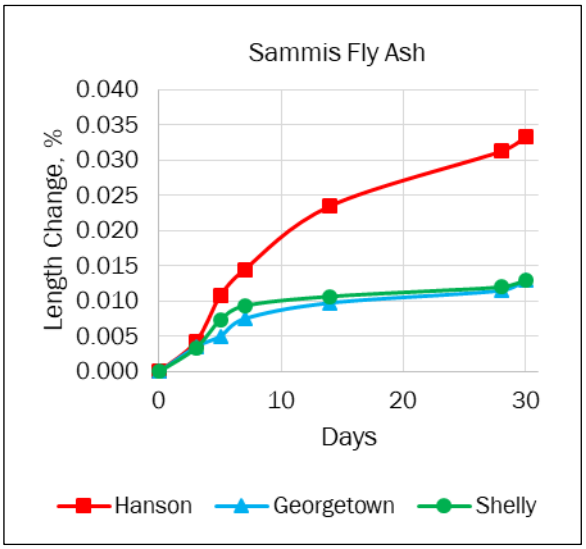
The average length change data are shown in Table 10 for all 12 combinations of materials using the Mix 7 design. Figure 4 compares the three aggregates tested against the four fly ash sources. Once again, the Hanson aggregate is the most reactive aggregate in Mix 7 regardless of the fly ash used. The highest 30-day length change was 0.0350% from a combination of the Longview fly ash and Hanson aggregate. The lowest 30-day length change was 0.0130% in two sources, i.e., the Georgetown aggregate and Sammis fly ash combination and the Shelly aggregate and Sammis fly ash combination.

Table 10. Average length change of mortar bars made from Mix 7 materials.

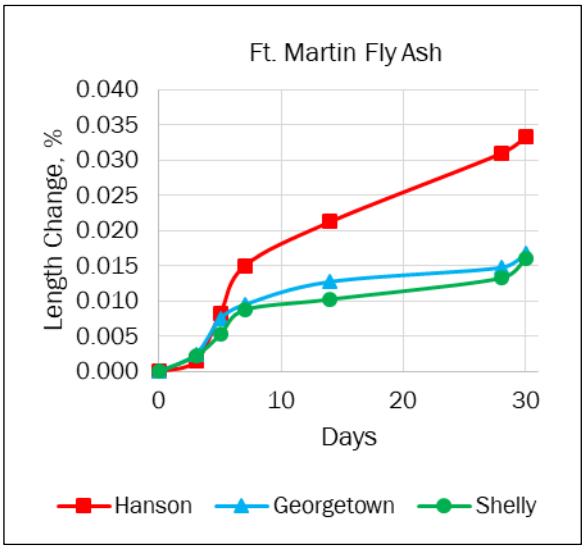
	Sammis Fly Ash			Ft. Martin Fly Ash			Longview Fly Ash			Brandon Shores Fly Ash		
Days	*H	*G	*S	*H	*G	*S	*H	*G	*S	*H	*G	*S
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0043	0.0035	0.0033	0.0015	0.0025	0.0023	0.0013	0.0033	0.0035	0.0027	0.0013	0.0005
5	0.0108	0.0050	0.0073	0.0083	0.0075	0.0053	-	-	-	0.0057	0.0043	0.0048
7	0.0145	0.0075	0.0093	0.0150	0.0095	0.0088	0.0037	0.0033	0.0050	0.0100	0.0045	0.0085
14	0.0235	0.0098	0.0107	0.0213	0.0128	0.0103	0.0137	0.0047	0.0063	0.0190	0.0098	0.0135
21	-	-	-	-	-	-	-	0.0100	0.0165	-	-	-
28	0.0313	0.0115	0.0120	0.0298	0.0148	0.0133	0.0380	0.0170	0.0188	0.0327	0.0173	0.0183
30	0.0333	0.0130	0.0130	0.0333	0.0168	0.0160	0.0350	0.0213	0.0223	0.0337	0.0195	0.0200

*Notes:
H - Hanson Aggregate
G - Georgetown Aggregate
S - Shelly Aggregate

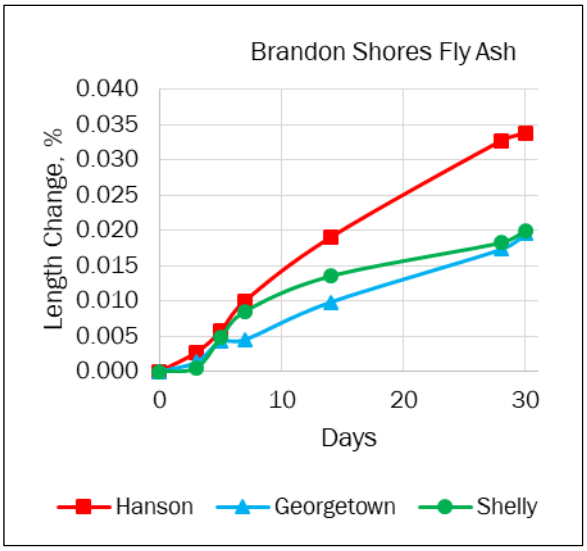
Figure 4. Mortar bar expansions versus time for Mix 7.



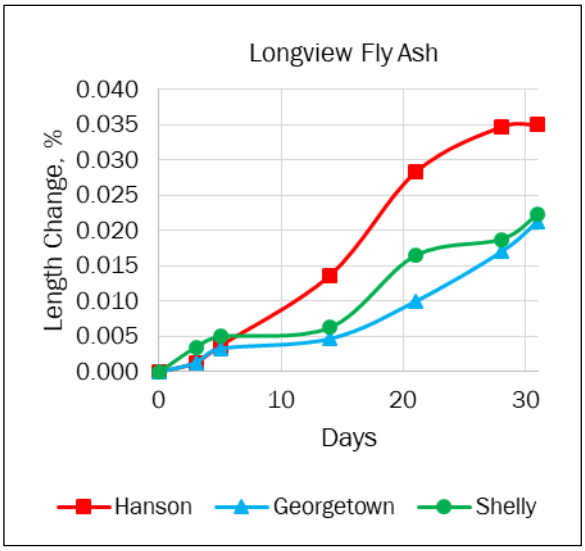
a) Sammis Fly Ash.



b) Ft. Martin Fly Ash.



c) Brandon Shores Fly Ash.



d) Longview Fly Ash.

4.2.4 Mix 10

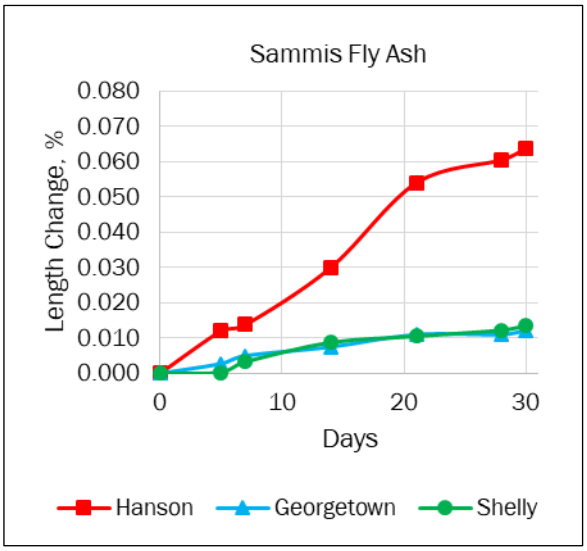
The average length change data are shown in Table 11 for all 12 combinations of materials using the Mix 10 design. Figure 5 compares the three aggregates tested against the four fly ash sources. The Hanson aggregate is the most reactive aggregate in Mix 10 regardless of the fly ash used, which is consistent with the other three mix designs. The highest 30-day length change was 0.0728% from a combination of the Longview fly ash and Hanson aggregate. The lowest 30-day length change was 0.0123% from a combination of the Georgetown aggregate and Sammis fly ash source.

Table 11. Average length change of mortar bars made from Mix 10 materials.

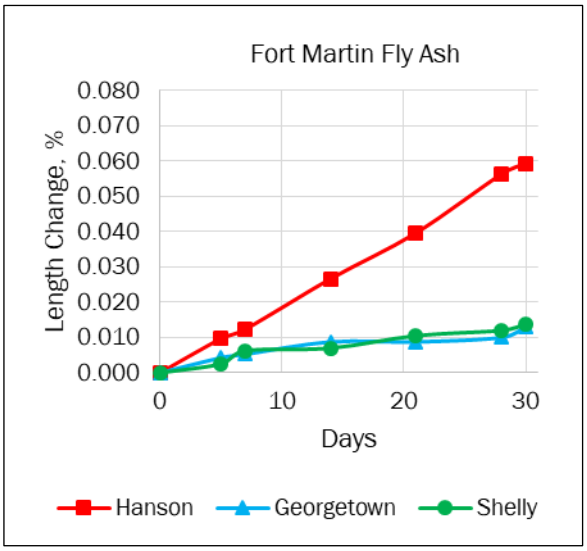
	Sammis Fly Ash			Ft. Martin Fly Ash			Longview Fly Ash			Brandon Shores Fly Ash		
Days	*H	*G	*S	*H	*G	*S	*H	*G	*S	*H	*G	*S
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	-	0.0047	-	-	-	-	0.0060	0.0003	0.0007	0.0028	0.0025	0.0010
5	0.0120	0.0037	0.0003	0.0097	0.0043	0.0025	-	-	-	0.0053	0.0028	0.0023
7	0.0138	0.0067	0.0033	0.0123	0.0053	0.0062	0.0113	0.0013	0.0033	0.0133	0.0033	0.0030
14	0.0300	0.0100	0.0088	0.0267	0.0088	0.0070	0.0290	0.0045	0.0043	0.0273	0.0070	0.0093
21	0.0540	0.0147	0.0105	0.0397	0.0088	0.0105	0.0408	0.0098	0.0070	-	-	-
28	0.0605	0.0147	0.0123	0.0563	0.0100	0.0120	0.0665	0.0165	0.0130	0.0565	0.0135	0.0143
30	0.0638	0.0163	0.0135	0.0593	0.0130	0.0138	0.0728	0.0188	0.0167	0.0593	0.0148	0.0150

***Notes:**
H - Hanson Aggregate
G - Georgetown Aggregate
S - Shelly Aggregate

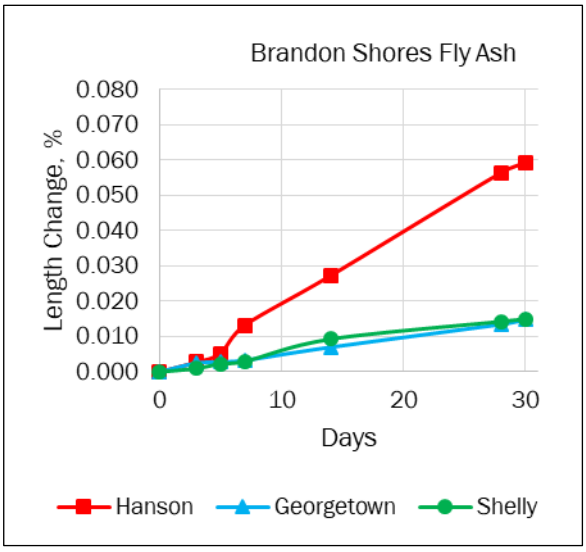
Figure 5. Mortar bar expansions versus time for Mix 10.



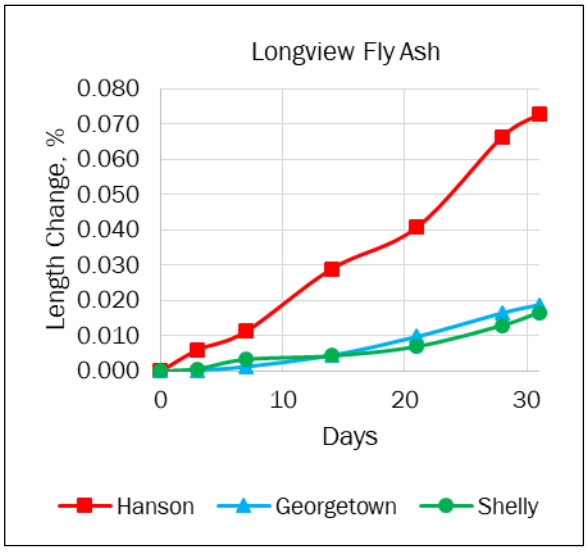
a) Sammis Fly Ash.



b) Ft. Martin Fly Ash.



c) Brandon Shores Fly Ash.



d) Longview Fly Ash.

5 Summary and Conclusions

This testing investigated the potential ASR reactivity of 3 aggregate sources in accordance to ASTM C1260 and the efficacy to mitigate expansion due to potential ASR using a combination of cementitious materials and aggregates in accordance to ASTM C1567. A total of 48 different mixtures were produced from a combination of four fly ash sources (Sammis, Fort Martin, Longview, and Brandon Shores), three aggregate sources (Shelly, Hanson, and Georgetown), and four mix designs (Mix 1, 5, 7, and 10). The following conclusions are made based on the results presented herein.

- All project aggregate sources (Hanson, Georgetown, and Shelly) are considered alkali-silica reactive based on the limiting criteria of the project specification, i.e., expansions less than 0.08% at 30 days, when tested in accordance to the ASTM C1260.
- The Hanson coarse aggregate source resulted in the highest 30-day expansion of 0.1970%, whereas the Georgetown and Shelly fine aggregate sources produced similar expansions of 0.1683% and 0.1623%, respectively.
- All 48 combinations of materials and mixture designs resulted in 30-day expansions less 0.08% when tested in accordance to the ASTM C1567. These results indicate that the constituent project materials in the proposed mix designs can effectively mitigate ASR.
- The Hanson aggregate/Longview fly ash combination resulted in the largest expansions of all four mix design groups. Final 30-day expansions with this aggregate/fly ash combination were 0.02% in Mix 1, 0.0595% in Mix 5, 0.035% in Mix 7, and 0.0728% in Mix 10.
- The Georgetown aggregate/Sammis fly ash combination resulted in the lowest expansions in Mix 1, Mix 7, and Mix 10. Final 30-day expansions with this aggregate/fly ash combination were 0.0073% in Mix 1, 0.013% in Mix 7, and 0.0123% in Mix 10. The highest lowest expansion in Mix 5 was 0.0147% from the Shelly aggregate/Fort Martin fly ash combination.
- Higher expansions in the Hanson coarse aggregate compared with the Shelly and Georgetown fine aggregates is possibly due to the additional crushing involved in the coarse aggregate source to the gradation sizes required for both the ASTM C1260 and ASTM C1567 testing.

Appendix A: Material Reports

A.1 Cementitious materials

	Report on Test Specification: ASTM C150, Standard Specification for Portland Cement	
US Army Corps of Engineers BUILDING STRONG.	Performing Orgnaization: US Army Engineer Research and Development Center Geotechnical and Structures Laboratory 3909 Halls Ferry Road Vicksburg, MS 39180-6199	Sponsoring Orgnaization: US Army Corps of Engineers Pittsburgh District, Lower Mon Area Office 1811 Schoonmaker Ave., Monesson, PA 15062

Material Description: Type II (MH) Cement
Manufacturer: Armstrong
Location: Cabot, PA
CMB Serial #: 150063
Project: Charleroi Lock and Dam Monongahela River Reconstruction Project

Chemical Analysis	Test Results	ASTM C150 Spec Limits; Type II (MH)
SiO_2, %	20.48	-
Al_2O_3, %	4.59	6.0% max
Fe_2O_3, %	6.3	[A]6.0% max
CaO, %	62.7	-
MgO, %	1.24	6.0% max
SO_3, %	2	3.0% max
Na2O, %	0.13	-
K2O, %	0.66	-
Equivalent Alkalies-total as Na2O, %	0.56	[B] 0.60% max
TiO2, %	0.32	-
Loss on ignition, %	0.45	3.0% max
Tricalcium silicate (C_3S)	54	-
Dicalcium silicate (C_2S)	18	-
Tricalcium aluminate (C_3A)	2	8.0% max
Tetracalcium aluminoferrite (C_3AF)	19	-
Sum of C_3S +4.75C_3A	63.5	100

Physical Analysis	Test Results	ASTM C150 Spec Limits; Type II (MH)
Air content, %; ASTM C 185	7.9	12% (max)
Surface area, m²/kg (air permeability); ASTM C 204	329	260 m²/kg (min)
Autoclave expansion, %; ASTM C 151	0.02	0.80% max
Initial set, min. (Vicat); ASTM C 191	155	45 (min)
Final set, min. (Vicat); ASTM C 191	290	375 (max)
Compressive strength, 3-day, (psi), ASTM C 109	1525	[B]1020 psi (min)
Compressive strength, 7-day, (psi); ASTM C 109	1920	[B]1740 psi (min)
Compressive strength, 28-day, (psi), ASTM C 109	4175	[C]3190 psi (min)
Heat of Hydration , 3-days, max, (kJ/kg); ASTM C 1702	185	[C]255 kJ/kg (max)
Heat of Hydration , 7-days, max, (kJ/kg); ASTM C 1702	240	-
Heat of Hydration , 28-days, max, (kJ/kg); ASTM C 1702	330	-
False set (final penetration), %; ASTM C 451	80	50% (min)

Remarks:
[A]Does not apply when heat of hydration limit in table 4 is specified
[B]Limit in table 2 for low-alkali cement
[C] Required only when optional heat of hydration in Table 4 is specified
[D] As specified in table 4 optional physical requirements

Tested by: MAR
Reviewed by: ABC

Information in this report shall not be used in advertising or sales promotion to indicate endorsement of this product by the U.S. Government.

US Army Corps of Engineers BUILDING STRONG®

Report on Test Specification: ASTM C 618, Standard Specification for Coal Fly Ash

Performing Orgnaization:	Sponsoring Orgnaization:
US Army Engineer Research and Development Center	US Army Corps of Engineers
Geotechnical and Structures Laboratory (CEERD-GMC)	Pittsburgh District, Lower Mon Area Office
3909 Halls Ferry Road Vicksburg, MS 39180-6199	1811 Schoonmaker Ave., Monessen, PA 15062

Material Description: Class F Fly Ash
Manufacturer: Ft. Martin Plant from Headwater Reasources
Location: Maidsville, WV
CMB Serial #: 150064
Project: Charleroi Lock and Dam Monongahela River Reconstruction Project

Chemical Analysis	Test Results	Spec Limits; Class F
SiO_2, %	52.6	-
Al_2O_3, %	22.5	-
Fe_2O_3, %	13.5	-
Sum, %	88.6	70.0% min
Na2O, %	2.49	-
K2O, %	2	-
CaO, %	1.1	-
MgO, %	0.9	-
SO_3, %	0.3	5.0% max
Loss on ignition, %	3.1	6.0% max
Moisture Content, %	0.13	3.0% max
Physical Analysis	**Test Results**	**Spec Limits; Class F**
Strength Activity Index,(%) 7-day, ASTM C311	64	75% min
Strength Activity Index, (%) 28-day, ASTM C311	65	75% min
Water Requirement, % control, ASTM C 311, C109	100	105% max
Specific Gravity, ASTM C188	2.52	5% max
Autoclave Soundness, %, ASTM C311, C151	0.001	0.8% max
Fineness, % Retained on #325; ASTM C311	23.85	34% max
Supplementary Optional Physical Analysis	**Test Results**	**Spec Limits; Class F**
Increase of drying shrinkage of mortar bars at 28 days, ASTM C618	0.001	-
Uniformity Requirement, amount of Vinsol, ASTM C618	0.2	-

Remarks:

[1]Armstrong Type II (MH) project cement used for reference cement

Tested by: MAR
Reviewed by: ABC

Information in this report shall not be used in advertising or sales promotion to indicate endorsement of this product by the U.S. Government.

	Report on Test Specification: ASTM C 618, Standard Specification for Coal Fly Ash	
US Army Corps of Engineers BUILDING STRONG.	Performing Orgnaization:	Sponsoring Orgnaization:
	US Army Engineer Research and Development Center	US Army Corps of Engineers
	Geotechnical and Structures Laboratory (CEERD-GMC)	Pittsburgh District, Lower Mon Area Office
	3909 Halls Ferry Road Vicksburg, MS 39180-6199	1811 Schoonmaker Ave., Monesson, PA 15062

Material Description: Class F Fly Ash
Manufacturer: W.H. Sammis Plant, Headwaters Reasources
Location: Stratton, OH
CMB Serial #: 150065
Project: Charleroi Lock and Dam Monongahela River Reconstruction Project

Chemical Analysis	Test Results	Spec Limits; Class F
SiO_2, %	44.2	-
Al_2O_3, %	20.2	-
Fe_2O_3, %	24.2	-
Sum, %	88.6	70.0% min
Na2O, %	2.87	-
K2O, %	2.05	-
CaO, %	0	-
MgO, %	0.9	-
SO_3, %	0.6	5.0% max
Loss on ignition, %	2.99	6.0% max
Moisture Content, %	0.11	3.0% max
Physical Analysis	**Test Results**	**Spec Limits; Class F**
Strength Activity Index,(%) 7-day, ASTM C311	71	75% min
Strength Activity Index, (%) 28-day, ASTM C311	72	75% min
Water Requirement, % control, ASTM C 311, C109	100	105% max
Specific Gravity, ASTM C188	2.6	5% max
Autoclave Soundness, %, ASTM C311, C151	0.001	0.8% max
Fineness, % Retained on #325; ASTM C311	25.92	34% max
Supplementary Optional Physical Analysis	**Test Results**	**Spec Limits; Class F**
Increase of drying shrinkage of mortar bars at 28 days, ASTM C618	0.05	-
Uniformity Requirement, amount of Vinsol, ASTM C618	0.2	-

Remarks:

[1]Armstrong Type II (MH) project cement used for reference cement

Tested by: MAR
Reviewed by: ABC

Information in this report shall not be used in advertising or sales promotion to indicate endorsement of this product by the U.S. Government.

Report on Test Specification: ASTM C 618, Standard Specification for Coal Fly Ash	
Performing Orgnaization:	Sponsoring Orgnaization:
US Army Engineer Research and Development Center Geotechnical and Structures Laboratory (CEERD-GMC) 3909 Halls Ferry Road Vicksburg, MS 39180-6199	US Army Corps of Engineers Pittsburgh District, Lower Mon Area Office 1811 Schoonmaker Ave., Monesson, PA 15062

Material Description: Class F Fly Ash
Manufacturer: Longview
Location: Maidsville, WV
CMB Serial #: 180005
Project: Charleroi Lock and Dam Monongahela River Reconstruction Project

Chemical Analysis	Test Results	ASTM C618 Spec Limits; Class F
SiO_2, %	50.81	-
Al_2O_3, %	21.75	-
Fe_2O_3, %	15.64	-
Sum, %	88.2	70.0% min
Na2O, %	0.62	-
K2O, %	2.36	-
CaO, %	3.37	-
MgO, %	1.07	-
SO_3, %	0.92	5.0% max
Loss on ignition, %	1.9	6.0% max
Moisture Content, %	0.13	3.0% max
Physical Analysis	**Test Results**	**ASTM C618 Spec Limits; Class F**
Initial Test	-	
Compressive strength, (psi) 7-day, [1]Reference ASTM C311	2410	-
Compressive strength, (psi) 28-day, [1]Reference, ASTM C311	3820	-
Compressive strength, (psi) 7-day, Fly Ash/Cement, ASTM C311	1640	-
Compressive strength, (psi) 28-day, Fly Ash/Cement, ASTM C311	2980	-
Strength Activity Index,(%) 7-day, ASTM C311	68	75% min
Strength Activity Index, (%) 28-day, ASTM C311	78	75% min
Second Test	-	
Compressive strength, (psi) 7-day, [1]Reference ASTM C311	2520	-
Compressive strength, (psi) 28-day, [1]Reference, ASTM C311	4080	-
Compressive strength, (psi) 7-day, Fly Ash/Cement, ASTM C311	1690	-
Compressive strength, (psi) 28-day, Fly Ash/Cement, ASTM C311	3190	-
Strength Activity Index,(%) 7-day, ASTM C311	67	75% min
Strength Activity Index, (%) 28-day, ASTM C311	78	75% min
Water Requirement, % control, ASTM C 311, C109	99	105% max
Specific Gravity, ASTM C188	2.34	5% max
Autoclave Soundness, %, ASTM C311, C151	-0.03	0.8% max
Fineness, % Retained on #325; ASTM C311	38.6	34% max
(Re-Test) Fineness, % Retained on #325; ASTM C311	38.5	34% max
Supplementary Optional Physical Analysis	**Test Results**	**ASTM C618 Spec Limits; Class F**
Increase of drying shrinkage of mortar bars at 28 days, ASTM C618	0.01	-
Uniformity Requirement, amount of Vinsol, ASTM C618	0.16 g	-

Remarks:

[1]Armstrong Type II (MH) project cement used for reference cement

Tested by: SLC
Reviewed by: MAR

Information in this report shall not be used in advertising or sales promotion to indicate endorsement of this product by the U.S. Government.

Report on Test Specification: ASTM C 618, Standard Specification for Coal Fly Ash	
Performing Organization:	Sponsoring Organization:
US Army Engineer Research and Development Center Geotechnical and Structures Laboratory (CEERD-GMC) 3909 Halls Ferry Road Vicksburg, MS 39180-6199	US Army Corps of Engineers Pittsburgh District, Lower Mon Area Office 1811 Schoonmaker Ave., Monesson, PA 15062

Material Description: Class F Fly Ash
Manufacturer: Brandon Shores
Location: Curtis Bay, MD
CMB Serial #: 180018
Project: Charleroi Lock and Dam Monongahela River Reconstruction Project

Chemical Analysis	Test Results	Spec Limits; Class F
SiO_2, %	45.95	-
Al_2O_3, %	22.42	-
Fe_2O_3, %	21.49	-
Sum, %	89.86	70.0% min
Na2O, %	0.45	-
K2O, %	1.85	-
CaO, %	2.64	-
MgO, %	0.79	-
SO_3, %	0.82	5.0% max
Loss on ignition, %	2	6.0% max
Moisture Content, %	0.3	3.0% max
Physical Analysis	**Test Results**	**Spec Limits; Class F**
Compressive strength, (psi) 7-day, [3]Reference ASTM C311	1785	-
Compressive strength, (psi) 28-day, [3]Reference, ASTM C311	3130	-
Compressive strength, (psi) 7-day, Fly Ash/Cement, ASTM C311	2320	-
Compressive strength, (psi) 28-day, Fly Ash/Cement, ASTM C311	4100	-
Strength Activity Index,(%) 7-day, ASTM C311	77	75% min
Strength Activity Index, (%) 28-day, ASTM C311	76	75% min
Water Requirement, % control, ASTM C 311, C109	98	105% max
Specific Gravity, ASTM C188	2.41	5% max
Autoclave Soundness, %, ASTM C311, C151	-0.06	0.8% max
Fineness, % Retained on #325; ASTM C311	19.12	34% max
Supplementary Optional Physical Analysis	**Test Results**	**Spec Limits; Class F**
Increase of drying shrinkage of mortar bars at 28 days, ASTM C618	0.01	-
Uniformity Requirement, amount of Vinsol, ASTM C618	0.15	-

Remarks:

[3]Armstrong Type II (MH) project cement used for reference cement

Tested by: SLC
Reviewed by: MAR

Information in this report shall not be used in advertising or sales promotion to indicate endorsement of this product by the U.S. Government.

Report on Test Specification: ASTM C 989, Standard Specification for Slag Cement

Performing Orgnaization:	Sponsoring Orgnaization:
US Army Engineer Research and Development Center	US Army Corps of Engineers
Geotechnical and Structures Laboratory (CEERD-GMC)	Pittsburgh District, Lower Mon Area Office
3909 Halls Ferry Road Vicksburg, MS 39180-6199	1811 Schoonmaker Ave., Monesson, PA 15062

Material Description: Slag Cement, Grade 100
Manufacturer: Argos-Essroc
Location: Middlebranch, OH
CMB Serial #: 150066
Project: Charleroi Lock and Dam Monongahela River Reconstruction Project

Chemical Analysis	Test Results	Spec Limits
Sulfide Sulfur, S %	2.02	2.5% max
Sulfate Sulfur, (as SO3) %	0.04	4% max
Aluminum Oxide, (as Al2O3) %	10.15	-
Chloride Content of Slag	0.05	-
Na2O, %	0.27	-
K2O, %	0.47	-
Equivalent Alkalies-total as Na2O, %	0.57	
Physical Analysis	**Test Results**	**Spec Limits**
Compressive strength (psi) 7-day [1]Reference ASTM C311	1880	-
Compressive strength (psi) 28-day [1]Reference, ASTM C311	3956	-
Compressive strength (psi) 7-day Slag/Cement, ASTM C311	1583	-
Compressive strength (psi) 28-day Slag/Cement, ASTM C311	3802	-
Strength Activity Index,(%) 7-day, ASTM C311	88	70% min
Strength Activity Index, (%) 28-day, ASTM C311	96	90% min
Surface area, m²/kg (air permeability); ASTM C 204	626	260 m²/kg min
Specific Gravity, ASTM C188	2.81	-
Fineness, % Retained on #325; ASTM C311	2.8	20% max
Air content, %; ASTM C 185	4.2	12% max

Remarks:

[1]Armstrong Type II (MH) project cement used for reference cement

Tested by: MAR
Reviewed by: ABC

Information in this report shall not be used in advertising or sales promotion to indicate endorsement of this product by the U.S. Government.

	Report on Test Specification: ASTM C1240, Silica Fume Used in Cementitious Mixtures	
US Army Corps of Engineers BUILDING STRONG®	Performing Orgnaization: US Army Engineer Research and Development Center Geotechnical and Structures Laboratory (CEERD-GMC) 3909 Halls Ferry Road Vicksburg, MS 39180-6199	Sponsoring Orgnaization: US Army Corps of Engineers Pittsburgh District, Lower Mon Area Office 1811 Schoonmaker Ave., Monesson, PA 15062

Material Description: Microsilica Grade 970 D
Manufacturer: Elkem Materials Inc.
Location: Pittsburgh, PA
CMB Serial #: 150066
Project: Charleroi Lock and Dam Monongahela River Reconstruction Project

Chemical Analysis	Test Results	ASTM C1240 Spec. Limits
SiO_2, %	95.16	85%, min.
Al_2O_3, %	0.24	-
Fe_2O_3, %	0.52	-
Sum, %	95.92	-
Na2O, %	0.3	-
K2O, %	0.49	-
MgO, %	0.25	-
SO_3, %	0.01	-
Loss on ignition, %	2.61	6%, max
Moisture %	0.61	3%, max
Physical Analysis	**Test Results**	**ASTM C1240 Spec. Limits**
Control Mixture[1]: Compressive strength, (psi) 7-day, ASTM C 311	1990	-
Test Mixture[2]: Compressive strength, (psi) 7-day, ASTM C 311	3280	-
Strength Activity Index,(%) 7-day, ASTM C311	165	105%, min
Water Requirement, ASTM C 311,C 109	[3]	100-115%
Specific Gravity, ASTM C188	2.32	-
Supplimentary Optional Physical Tests	**Test Results**	**ASTM C1240 Spec. Limits**
Uniformity Requirement, amount of Vinsol, ASTM C618	0.04 g	-
Effectiveness in Controlling ASR at 14 days, ASTM C618, C311, C441	95%	80%, min.

Remarks:

[1],[2] Armstrong Type II (MH) project cement used for reference cement

[3] Following the standard ASTM C1240 method, 2 mL of HRWRA required with test mixture to produce flow limits using 242 mL of water

Tested by: MAR
Reviewed by: ABC

Information in this report shall not be used in advertising or sales promotion to indicate endorsement of this product by the U.S. Government.

A.2 Aggregate materials

Summary of Aggregate Tests Report									
Material Description:	3/4-inch limestone aggregate			Performing Organizaion:	Geotechnical and Structures Lab				
Source:	Hanson Aggregates				Concrete and Materials Branch				
Location:				Tested by:	R. Hardy				
CMB Log in #:	150070			Reviewed by:	J. Burroughs/M. Ramsey				
Sponsoring Organization:	USACE Pittsburgh District, Lower Mon Area Office								
Project:	Charleroi Lock and Dam Monongahela River Reconstruction Project								
ASTM C 136: Sieve Analysis:									
Sieve Size	Run 1		Cumulative Percent		Run 2		Cumulative Percent		Avg % Passing
	Mass Ret, g	% Ret.	Ret.	Pass	Mass Ret, g	% Ret.	Ret.	Pass	
3 in	0.0	0.00%	0.00%	100.00%	0.0	0.00%	0.00%	100.00%	100%
2 1/2 in	0.0	0.00%	0.00%	100.00%	0.0	0.00%	0.00%	100.00%	100%
2 in	0.0	0.00%	0.00%	100.00%	0.0	0.00%	0.00%	100.00%	100%
1 1/2 in	0.0	0.00%	0.00%	100.00%	0.0	0.00%	0.00%	100.00%	100%
1 in	0.0	0.00%	0.00%	100.00%	0.0	0.00%	0.00%	100.00%	100%
3/4 in	265.1	3.21%	3.21%	96.79%	255.1	3.07%	3.07%	96.93%	97%
1/2 in	4418.7	53.44%	56.65%	43.35%	4022.8	48.44%	51.51%	48.49%	46%
3/8 in	2306.2	27.89%	84.54%	15.46%	2544.6	30.64%	82.15%	17.85%	17%
No. 4	1017.2	12.30%	96.85%	3.15%	1076.2	12.96%	95.10%	4.90%	4%
No. 8	177.5	2.15%	98.99%	1.01%	285.8	3.44%	98.55%	1.45%	1%
Pan	83.1	1.01%	100.00%		120.8	1.45%	100.00%		
Total	8267.8	100.00%			8305.3				
ASTM C 117: Minus 75um (No. 200)									
OD Mass, g	9427.7	Mass Aft,g	9359.2	Mass Loss, g	68.5			% Loss:	0.73%
ASTM C 127: Bulk Specific Gravity & Absorption:									
							Run 1	Run 2	Avg
SSD Mass in Air, g							3142.6	3529.7	
SSD Mass in Water, g							1965.1	2207.5	
Displaced Water, g							1177.5	1322.2	
Water Temp C							22.7	22.7	
Relative Density (Bulk Specific Gravity)(SSD)							2.669	2.670	2.67
Oven Dry Mass, g							3123.4	3508.8	
Moisture Loss, g							19.2	20.9	
Absorption							0.61%	0.60%	0.61%
ASTM C 88 Magnesium Sulfate Soundness (5 cycles):									
	Gradation > 5%	OD Mass, g	Mass Aft, g	Mass Loss, g	% Loss	Wt'ed %			
2 1/2 in	0.00%	1.0	1.0	0.0	0.00	0.0%			
2 in	0.00%	1.0	1.0	0.0	0.00	0.0%			
1 1/2 in	0.00%	1.0	1.0	0.0	0.00	0.0%			
1 in	0.00%	1.0	1.0	0.0	0.00	0.0%			
3/4 in	3.21%	674.4	668.0	6.4	0.01	0.0%			
1/2 in	53.44%	674.4	668.0	6.4	0.01	0.5%			
3/8 in	27.89%	1004.6	978.6	26.0	0.03	0.7%			
No. 4	12.30%	280.9	280.9	0.0	0.00	0.0%			
No. 8	2.15%	280.9	280.9	0.0	0.00	0.0%			
Total	98.99%					1.3%			1.3%
ASTM C 123 Light Weight Particles and Pieces in Aggregate									
Zinc Bromide 2.40 sp.gr.			No mat'l. lighter than 2.00 sp.gr.						
OD Mass, g	3004.0	Ret Mass, g	2959.7	Mass Loss, g	44.3	% Loss:	1.47%		1.5%
ASTM C131 or C535 LA Abrasion Resistance (500 rev)									
Grading:	B	OD Mass, g	5009.9	Ret Mass, g	3903.8	% Loss:	22.08%		22.1%
ASTM C 142: Clay Lumps & Friable Particles:									
	Gradation >5%	OD Mass, g	Mass Aft, g	Mass Loss, g	% Loss	Wt'ed %			
2 1/2 in	0.00%	1.0	1.0	0.0	0.00	0.0%			
2 in	0.00%	1.0	1.0	0.0	0.00	0.0%			
1 1/2 in	0.00%	1.0	1.0	0.0	0.00	0.0%			
1 in	0.00%	1.0	1.0	0.0	0.00	0.0%			
3/4 in	3.21%	2037.7	2035.4	2.3	0.00	0.0%			
1/2 in	53.44%	2037.7	2035.4	2.3	0.00	0.1%			
3/8 in	27.89%	2001.1	1999.2	1.9	0.00	0.0%			
No. 4	12.30%	1007.0	1002.4	4.6	0.00	0.1%			
Total	96.85%					0.1%			0.1%
ASTM D 4791 Flat or Elongated Particles:									
3:1 Ratio	Gradation >10%	Pcs Before	Flat Pcs	Elong Pcs	F&E Pcs	% F,E&FE	Wt'ed %		
2 1/2 in	0.00%	100	0	0	0	0.00	0.0%		
2 in	0.00%	100	0	0	0	0.00	0.0%		
1 1/2 in	0.00%	100	0	0	0	0.00	0.0%		
1 in	0.00%	100	0	0	0	0.00	0.0%		
3/4 in	3.21%	100	0	0	0	0.00	0.0%		
1/2 in	53.44%	107	0	0	0	0.00	0.0%		
3/8 in	27.89%	120	0	0	0	0.00	0.0%		
No. 4	12.30%	102	0	0	0	0.00	0.0%		
Total	96.85%						0.0%		0.0%

Summary of Aggregate Tests Report									
Material Description:	Fine Aggregate				Performing Organizaion:	Geotechnical and Structures Lab			
Source:	Georgetown Sand & Gravel					Concrete and Materials Branch			
Location:	Georgetown, PA				Tested by:	R. Hardy			
CMB Log in #:	150069				Reviewed by:	J. Burroughs/M. Ramsey			
Sponsoring Organization:	USACE Pittsburgh District, Lower Mon Area Office								
Project:	Charleroi Lock and Dam Monongahela River Reconstruction Project								
ASTM C 136 Sieve Analysis:									
Sieve Size	Run 1		Cumulative Percent		Run 2		Cumulative Percent		Avg % Passing
	Mass Ret, g	% Ret.	Ret.	Pass	Mass Ret, g	% Ret.	Ret.	Pass	
3/8 in.	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%
No. 4	10.60	2.19%	2.19%	97.81%	9.30	2.02%	2.02%	97.98%	98%
No. 8	53.90	11.11%	13.30%	86.70%	55.00	11.94%	13.96%	86.04%	86%
No. 16	63.00	12.99%	26.29%	73.71%	56.20	12.20%	26.17%	73.83%	74%
No. 30	89.80	18.52%	44.80%	55.20%	85.90	18.65%	44.82%	55.18%	55%
N0. 40	106.80	22.02%	66.82%	33.18%	102.70	22.30%	67.12%	32.88%	33%
No. 50	95.30	19.65%	86.47%	13.53%	88.60	19.24%	86.36%	13.64%	14%
No. 100	54.00	11.13%	97.61%	2.39%	51.30	11.14%	97.50%	2.50%	2%
No. 200	10.40	2.14%	99.75%	0.25%	9.90	2.15%	99.65%	0.35%	0%
Pan	1.20	0.25%	100.00%		1.60	0.35%	100.00%		
Total	485.00	100.00%			460.50				
Fineness Modulus:			2.707				2.708		2.71
ASTM C 117 Minus 75um (No. 200)									
OD Mass, g	489.90	Mass Aft, g	485	Mass Loss, g	4.90	% Loss:	1.00%		Avg Loss
OD Mass, g	464.40	Mass Aft, g	460.7	Mass Loss, g	3.70	% Loss:	0.80%		0.9%
ASTM C 127: Bulk Specific Gravity & Absorption:									
							Run 1	Run 2	Avg
SSD Mass, g							503.80	507.90	
Mass Flask+Water, g							1261.80	1474.60	
Mass Flask+Water+Material, g							1573.50	1788.30	
Mass Displaced Water, g							192.10	194.20	
Water Temp C							22.7	22.7	
Relative Density (Bulk Specific Gravity)(SSD)							2.623	2.615	2.62
SSD Mass, g							503.80	507.90	
Oven Dry Mass, g							496.90	500.90	
Moisture Loss, g							690.00%	700.00%	
Absorption							1.39%	1.40%	1.39%
ASTM C 40 Organic Impurity Color Plate Number:									2
ASTM C 88 Magnesium Sulfate Soundness (5 cycles):									
	Gradation > 5%	OD Mass, g	Mass Aft, g	% Loss	Wt'ed % Loss				
No. 4	2%	0.00	0.00						
No. 8	12%	100.40	88.40	12.0%	1.38%				
No. 16	13%	100.40	88.70	11.7%	1.47%				
No. 30	19%	100.60	87.80	12.7%	2.36%				
No. 50	19%	100.30	89.50	10.8%	2.09%				
No. 100	11%	100.00	92.10	7.9%	0.88%				
Total					8.18%				8.2%
ASTM C 123 Light Weight Particles and Pieces in Aggregate									
Zinc Bromide 2.40 sp.gr.									
OD Mass, g	477.1	Mass Aft, g	471.20					% Loss:	1.2%
Zinc Chloride 2.00 sp.gr.									
OD Mass, g	471.2	Mass Aft, g	465.40					% Loss:	1.2%
ASTM C 142 Clay Lumps & Friable Particles:									
OD Mass, g	270.1	Mass Aft, g	269.80	Loss, g	0.30			Loss, %	0.11%

Summary of Aggregate Tests Report									
Material Description:	Fine Aggregate			Performing Organizaion:		Geotechnical and Structures Lab			
Source:	Shelly Materials					Concrete and Materials Branch			
Location:	Thornville, OH			Tested by:		R. Hardy			
CMB Log in #:	160004			Reviewed by:		J. Burroughs/M. Ramsey			
Sponsoring Organization:	USACE Pittsburgh District, Lower Mon Area Office								
Project:	Charleroi Lock and Dam Monongahela River Reconstruction Project								
ASTM C 136 Sieve Analysis:									
Sieve Size	Run 1		Cumulative Percent		Run 2		Cumulative Percent		Avg % Passing
	Mass Ret, g	% Ret.	Ret.	Pass	Mass Ret, g	% Ret.	Ret.	Pass	
3/8 in.	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%
No. 4	5.90	1.09%	1.09%	98.91%	6.10	1.11%	1.11%	98.89%	99%
No. 8	55.60	10.27%	11.36%	88.64%	57.90	10.56%	11.67%	88.33%	88%
No. 16	60.90	11.25%	22.61%	77.39%	59.10	10.78%	22.45%	77.55%	77%
No. 30	112.50	20.78%	43.39%	56.61%	112.60	20.53%	42.98%	57.02%	57%
N0. 40	146.50	27.06%	70.45%	29.55%	150.40	27.43%	70.40%	29.60%	30%
No. 50	98.60	18.21%	88.66%	11.34%	98.30	17.92%	88.33%	11.67%	12%
No. 100	52.10	9.62%	98.28%	1.72%	53.70	9.79%	98.12%	1.88%	2%
No. 200	8.50	1.57%	99.85%	0.15%	8.80	1.60%	99.73%	0.27%	0%
Pan	0.80	0.15%	100.00%		1.50	0.27%	100.00%		
Total	541.40	100.00%			548.40	100.00%			
Fineness Modulus:			2.654				2.647		2.65
ASTM C 117 Minus 75um (No. 200)									
OD Mass, g	544.40	Mass Aft, g	541.4	Mass Loss, g	3.00	% Loss:	0.55%		Avg Loss
OD Mass, g	551.90	Mass Aft, g	548.4	Mass Loss, g	3.50	% Loss:	0.63%		0.6%
ASTM C 127: Bulk Specific Gravity & Absorption:									
							Run 1	Run 2	Avg
SSD Mass, g							508.60	505.10	
Mass Flask+Water, g							1263.50	1479.20	
Mass Flask+Water+Material, g							1576.30	1790.10	
Mass Displaced Water, g							195.80	194.20	
Water Temp C							21.8	21.8	
Relative Density (Bulk Specific Gravity)(SSD)							2.598	2.601	2.60
Oven Dry Mass, g							499.90	496.60	
Moisture Loss, g							8.70	8.50	
Absorption							1.74%	1.71%	1.7%
ASTM C 40 Organic Impurity Color Plate Number:									2
ASTM C 88 Magnesium Sulfate Soundness (5 cycles):				New Solution 1.299 sp.gr.					
Gradation > 5%		OD Mass, g	Mass Aft, g	% Loss	Wt'ed % Loss				
No. 4	1%			11.1%	0.12%				
No. 8	10%	100.00	88.90	11.1%	1.16%				
No. 16	11%	100.00	86.80	13.2%	1.45%				
No. 30	21%	100.10	81.90	18.2%	3.76%				
Nos. 40 & 50	45%	100.10	90.70	9.4%	4.25%				
No. 100	10%								
Minus No. 100	2%								
Total	100%				10.62%				10.6%
ASTM C 123 Light Weight Particles and Pieces in Aggregate									
Zinc Bromide 2.40 sp.gr.									
OD Mass, g	531.5	Mass Aft, g	525.60					% Loss:	1.11%
Zinc Chloride 2.00 sp.gr.									
OD Mass, g	535.3	Mass Aft, g	531.40					% Loss:	0.73%
ASTM C 142 Clay Lumps & Friable Particles:									
OD Mass, g	156.2	Mass Aft, g	155.80	Loss, g	0.40			Loss, %	0.26%

US Army Corps of Engineers BUILDING STRONG®	**Report on Test Specifications:**	**ASTM C1271 and C1301 for chemical properties and ASTM D546 and D4318 for physical properties of limestone powder.**
	Performing Orgnaization:	Sponsoring Orgnaization:
	U.S Army Engineer Research and Development Center	U.S. Army Corps of Engineers
	Geotechnical and Structures Laboratory (CEERD-GMC)	Pittsburgh District, Lower Mon Area Office
	3909 Halls Ferry Road	1811 Schoonmaker Ave.,
	Vicksburg, MS 39180-6199	Monesson, PA 15062

Material Description:	Limestone Powder
Manufacturer:	Graymont Limestone
Location:	Pleasant Gap, PA
CMB Serial #:	150067
Project:	Charleroi Lock and Dam Monongahela River Reconstruction Project

Chemical Analysis	**Test Results**
SiO_2, %	0.95
Al_2O_3, %	0.38
Fe_2O_3, %	0.15
CaO, %	54.18
Na2O, %	0.04
K2O, %	0.09
MgO, %	0.71
C, %	0.17
Loss on ignition (950°C), %	43.29
Calculated Compounds	
Ca as $CaCO_3$, %	96.69
Mg as $MgCO_3$, %	1.49
Calculated Carbonates as CO_2	43.29
L.O.I. / CO_2 Balance	1
Calculated Compounds- Mg as Dolomite	
Mg as $CaMg(CO_3)_2$, %	3.26
Residual Ca as $CaCO_3$, %	94.92

ASTM D 546 Sieve Analysis of Mineral Filler for Bituminous Paving Mixtures:

Sieve Size	Run 1		Cumulative Percent		Run 2		Cumulative Percent		
	Mass Retained, g	% Retained	% Retained	% Passing	Mass Retained, g	% Retained	% Retained	% Passing	Avg. % Passing
No. 16	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100.00%
No. 30	0.52	0.51%	0.51%	99.49%	0.60	0.53%	0.53%	99.47%	99.48%
No. 50	0.50	0.49%	1.00%	99.00%	0.58	0.51%	1.04%	98.96%	98.98%
No. 100	1.93	1.89%	2.89%	97.11%	2.08	1.83%	2.87%	97.13%	97.12%
No. 200	22.00	21.56%	24.45%	75.55%	24.16	21.25%	24.12%	75.88%	75.72%
Minus No.200	77.09	75.55%	100.00%		86.28	75.88%	100.00%		
Original Sample	102.04	100.00%			113.70	100.00%			

Remarks: Limestone powder material is considered non-plastic Silty Sand (SM), Gray when tested in accordance to ASTM D4318

A.3 Admixtures materials

The Euclid Chemical Company

EUCON AEA-92

AIR ENTRAINING AGENT FOR CONCRETE

EUCLID CHEMICAL

AIR ENTRAINERS

EUCON AEA-92

MASTER FORMAT #:
03 30 00 03 40 00
03 70 00

DESCRIPTION

EUCON AEA-92 is formulated for use as an air entraining admixture for concrete of all types and is manufactured under rigid control which assures uniform and precise performance. It should be added to the mix independently and not with other admixtures.

PRIMARY APPLICATIONS

- Ready mix concrete
- Structural concrete
- Mass concrete
- Paving concrete
- All exterior concrete

FEATURES/BENEFITS

- Provides a stable air void system with proper bubble size and spacing. This air void system protects concrete against damage caused by repeated freeze/thaw cycles
- Concrete is made more resistant to de-icing salts, sulfate attack and corrosive water
- Less mixing water can be used per yard (meter) of concrete and placeability is improved
- Minimizes bleeding and segregation of the concrete

TECHNICAL INFORMATION

EUCON AEA-92 is an aqueous solution compound of synthetic organic chemicals. It is compatible with concrete mixes containing calcium chloride, water reducing admixtures, retarding admixtures, or high range water reducers.

PACKAGING

EUCON AEA-92 is packaged in bulk, 275 gal (1041 L) totes, 55 gal (208 L) drums and 5 gal (18.9 L) pails.

SHELF LIFE

2 years in original, unopened package.

SPECIFICATIONS/COMPLIANCES

EUCON AEA-92 meets or exceeds the requirements of the following specifications:

- Corps of Engineers Specification CRD C-13
- ASTM Specification C 260
- AASHTO Specification M 154
- ANSI/NSF STD 61

19215 Redwood Road • Cleveland, OH 44110
800-321-7628 t • 216-531-9596 f
www.euclidchemical.com

DIRECTIONS FOR USE

EUCON AEA-92 is typically dosed at a rate of 0.1 to 4 oz per 100 lbs (6 to 260 mL per 100 kg) of total cementitious material to entrain 3% - 6% air content. The amount of EUCON AEA-92 will vary depending on type of cement, fineness of sand, temperature, design of the mix, other admixtures, etc. Concrete mixes must be tested regularly to confirm that proper air content is achieved. EUCON AEA 92 should be added directly to the sand to achieve maximum performance.

PRECAUTIONS/LIMITATIONS

- Protect EUCON AEA-92 from freezing.
- Consult your local Euclid Chemical representative for the proper dosage rate adjustments when using fly ash, slag or high range water reducers.
- Add to the mix independent of other admixtures.
- In all cases, consult the Safety Data Sheet before use.

The Euclid Chemical Company

EUCON RETARDER 75

Concrete Water Reducing Set Controlling Retarder

EUCLID CHEMICAL

RETARDERS

EUCON RETARDER 75

MASTER FORMAT #:
03 30 00 03 40 00
03 70 00

Description

EUCON RETARDER 75 is a synthetically produced liquid water-reducing and set retarding admixture for concrete. EUCON RETARDER 75 does not contain calcium chloride or other potential corroding materials, and may be used in the presence of aluminum or zinc metals. It is compatible with air-entraining agents, water reducers and calcium chloride, but they must be added separately to the mix.

Primary Applications

- Prestressed concrete
- Concrete requiring water reduction and set time control
- Architectural concrete
- Hot weather concrete placement

Features/Benefits

Plastic Concrete
- Retards setting characteristics
- Improves finishability
- Improves workability
- Reduces water requirements
- Reduces segregation

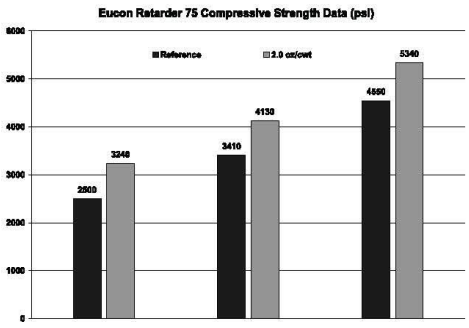
Hardened Concrete
- Increases strengths
- Improves finished appearance
- Reduces cracking
- Reduces permeability
- Non staining

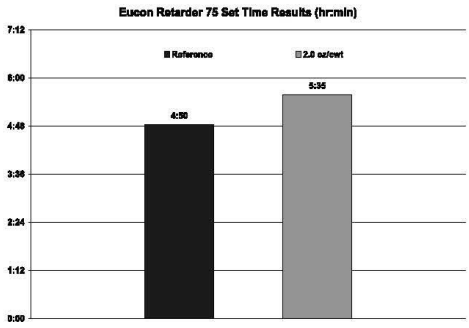
Technical Information

Perfomance Data

The following test results were achieved using typical ASTM C 494 mix design requirements, 517 lb/yd^3 (307 kg/m^3) cement content and similar (± 0.5)% air content.

These results were obtained under laboratory conditions with materials and mix designs meeting the specifications of ASTM C 494. Changes in materials and mix designs can affect the dosage response of EUCON RETARDER 75.





PACKAGING

EUCON RETARDER 75 is packaged in bulk, 275 gal (1041 L) totes, 55 gal (208 L) drums and 5 gal (18.9 L) pails.

SHELF LIFE

1 year in original, unopened container.

SPECIFICATIONS/COMPLIANCES

- ASTM C 494, Types B & D
- AASHTO M 194
- ANSI/NSF STD 61

DIRECTIONS FOR USE

EUCON RETARDER 75 is normally used at dosages of 2 to 5 oz per 100 lb (130 to 330 ml per 100 kg) of cementitious material, depending on the application. Higher dosages are acceptable with prior testing and confirmation of the desired performance with specific materials being used.

EUCON RETARDER 75 should be added to the initial batch water of the concrete mixture. Do not dispense onto dry cement.

PRECAUTIONS/LIMITATIONS

- Care should be taken to maintain EUCON RETARDER 75 above freezing; however, freezing and subsequent thawing will not harm the material if thoroughly agitated.
- Add to mix independent of other admixtures.
- In all cases, consult the Safety Data Sheet before sue.

Rev. 6.17

The Euclid Chemical Company

EUCON WR

Water Reducing Admixture

EUCLID CHEMICAL

Description

EUCON WR is an aqueous solution of refined lignosulfonate which is completely free of any added chloride ions. It is a water-reducing, normal-set admixture for concrete. It provides a more plastic and cohesive mix in the fresh concrete and better durability, reduced shrinkage and less permeability in the hardened concrete.

Primary Applications

- Ready mixed concrete
- Prestressed concrete
- Precast concrete
- General use concrete
- Lightweight concrete
- Expansive concrete

Features/Benefits

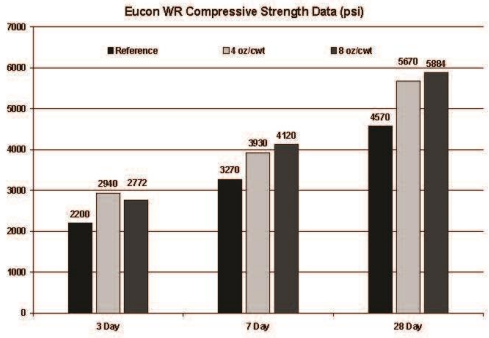
- Provides easier handling and finishing
- Increases strength
- Provides increased durability
- Reduces shrinkage and permeability

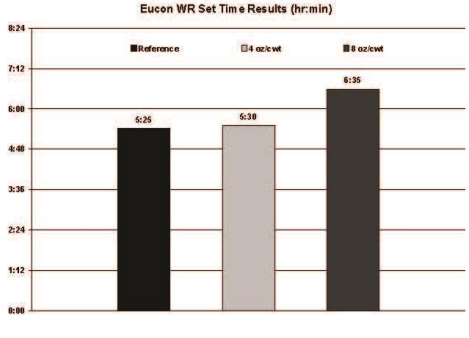
Technical Information

Perfomance Data

The following test results were achieved using typical ASTM C 494 mix design requirements, 517 lb/yd^3 (307 kg/m^3) cement content and similar (± 0.5)% air content.

These results were obtained under laboratory conditions with materials and mix designs meeting the specifications of ASTM C 494. Changes in materials and mix designs can affect the dosage response of EUCON WR.





19215 Redwood Road • Cleveland, OH 44110
800-321-7628 t • 216-531-9596 f
www.euclidchemical.com

PACKAGING

EUCON WR is packaged in bulk, 275 gal (1041 L) totes, 55 gal (208 L) drums and 5 gal (18.9 L) pails.

SHELF LIFE

1 year in original, unopened container.

SPECIFICATIONS/COMPLIANCES

EUCON WR meets or exceeds the requirements of:

- ASTM C 494, Type A, Type B and Type D
- AASHTO M 194

DIRECTIONS FOR USE

EUCON WR is typically used at dosages of 2 to 10 fl oz/cwt (130 to 650 mL/100 kg) of cementitious materials. Higher dosages are acceptable with prior testing and confirmation of the desired performance with specific materials being used.

EUCON WR admixture has been tested as per ASTM C494 at a Type A dosage of 4 fl oz/cwt (260mL/100 kg) of cementitious materials and at 8 fl oz/cwt (520 mL/100 kg) of cementious materials for Type B and D requirements.

Because of variations in job conditions and concrete materials, dosages other than the recommended amounts may be required. In such cases, contact your local Euclid sales representative.

EUCON WR should be added to the initial batch water of the concrete mixture. Do not dispense onto dry cement.

PRECAUTIONS/LIMITATIONS

- Care should be taken to maintain EUCON WR above freezing; however, freezing and subsequent thawing will not harm the material if thoroughly agitated.
- Add to mix independent of other admixtures.
- In all cases, consult the Safety Data Sheet before use.

Rev. 5.18

The Euclid Chemical Company

EUCON AWA

Anti-Washout Admixture

EUCLID CHEMICAL

Description

EUCON AWA is a ready to use liquid admixture designed to prevent the loss of cement and fine aggregate during the placement of underwater concrete. EUCON AWA is a blend of different powerful ingredients and colloidal agents that act primarily on the water preventing the cement paste from washing out during casting under water. EUCON AWA provides superior slump retention while greatly reducing the environmental impact due to cement wash out in below water applications.

Primary Applications

- Underwater bridge repair
- Dam repair below the waterline
- Underwater grouting and mortar application
- Damming underground rivers/lakes in mining operations
- Anti-segregation aid for use with lightweight and heavyweight aggregates
- Reduction or elimination of concrete bleed water for use with fast track construction

Features/Benefits

- Minimal environmental impact due to cement washout
- Eliminates the need for expensive de-watering during underwater construction
- Greatly reduces or eliminates concrete bleed water
- Superior slump retention
- Does not effect water demand when slump is maintained
- Easily metered with standard admixture dispensing equipment

Technical Information

Appearance

EUCON AWA is a medium viscosity, dark brown liquid which will not discolor concrete.

Packaging

EUCON AWA is packaged in 275 gal (1041 L) totes, 55 gal (208 L) drums and 5 gal (18.9 L) pails.

Shelf Life

6 months in original, unopened container.

Specifications/Compliances

- Meets ASTM C 494 Types S

19215 Redwood Road • Cleveland, OH 44110
800-321-7628 t • 216-531-9596 f
www.euclidchemical.com

Directions for Use

Underwater Applications

To reduce the washout of cement and fine aggregates when placing concrete underwater, 10 to 32 oz per 100 lb (0.65 to 2.1 L/100 kg) of cement is recommended. At a dosage rate of 25 oz per 100 lb (1.6 L/100 kg) of cement, set retardation may be 6 to 10 hours. In non air entrained concrete applications, the concrete should be batched and the slump adjusted either with water or HRWR prior to the addition of EUCON AWA.

Do not use water to adjust slump after EUCON AWA has been dispensed, instead, adjust slump through the use of a superplasticizer such as EUCON 37. Contact Euclid Chemical for a product recommendation.

If air entrainment is desired, the addition of the air entraining admixture should be done at the beginning of the batching sequence. EUCON AWA should be added before the HRWR to insure an adequate air void system.

For further recommendations on underwater concreting and underwater concrete mix designs, please consult the ACI 304, "Measuring, Mixing, Transporting and Placing Concrete".

Precautions / Limitations

- Do not allow material to freeze
- Superplasticizers must be used to increase slump after the addition of EUCON AWA
- Significant set retardation may occur with the use of this product
- In all cases, consult the Safety Data Sheet before use.

The Euclid Chemical Company

EUCON 37

High Range Water Reducer - Superplasticizer

EUCLID CHEMICAL

Description

EUCON 37 is a high range water-reducing admixture. It may be added to the concrete at the job site or at the ready mix concrete plant. EUCON 37 is formulated to retain plastic consistancy for 30-60 minutes after dosing depending on the initial slumps, dosage rates, and ambient temperature. No chlorides are used in its formulation; consequently, it is recommended for prestressed concrete. It is also compatible with air-entraining agents, waterproofing agents, calcium chloride and many other admixtures; however, each material should be added to the concrete separately.

Primary Applications

- High performance concrete
- General ready mix concrete
- Heavily reinforced concrete
- Flatwork and mass concrete
- Minimum water content concrete
- Low water/cement ratio concrete
- High slump, flowable concrete

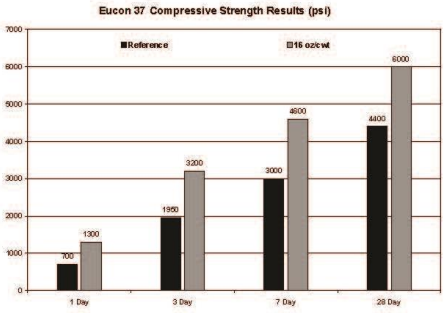
Features/Benefits

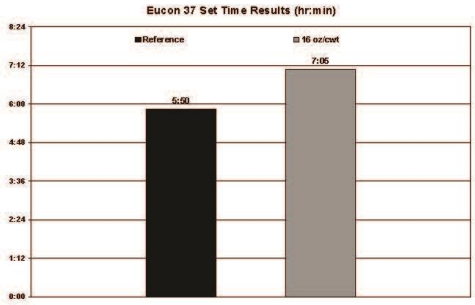
- Produces low water content and low water/cement ratio concrete allowing higher strengths
- Produces flowing concrete with better than normal strengths
- Aids in concrete placement and reduces labor cost
- When used in precast work with Type I cement will produce the high early strengths

Technical Information

Performance Data:

The following test results were achieved using typical ASTM C 494 mix design requirements, 517 lb/yd^3 (307 kg/m^3) cement content and similar (± 0.5)% air content. These results were obtained under laboratory conditions with materials and mix designs meeting the specifications of ASTM C 494. Changes in materials and mix designs can affect the dosage response of EUCON 37.





19215 Redwood Road • Cleveland, OH 44110
800-321-7628 t • 216-531-9596 f
www.euclidchemical.com

PACKAGING

EUCON 37 is packaged in bulk, 275 gal (1041 L) totes, 55 gal (208 L) drums and 5 gal (18.9 L) pails.

SHELF LIFE

2 years in original, unopened package.

SPECIFICATIONS/COMPLIANCES

- Fully complies with the requirements of ASTM C 494, Types A & F admixtures.
- Fully complies with the requirements of AASHTO M 194.

DIRECTIONS FOR USE

EUCON 37 can be added to the initial batch water or directly on the freshly batched concrete and mixed for approximately 5 minutes or 70 revolutions. However, better results have been observed batching directly on the freshly batched concrete. It should not come into contact with dry cement or other admixtures until mixed thoroughly with the concrete batch.

EUCON 37 is typically used at dosages of 6 to 18 oz per 100 lbs (400 to 1170 mL per 100 kg) of cementitious material. Other dosages are acceptable with prior testing and confirmation of the desired performance with specific materials being used.

For any concrete application including Self-Consolidating Concrete (SCC), the dosage of EUCON 37 will vary depending on the mix design, local materials, and individual needs of the concrete producer. Trial mixes should be run to verify plastic and hardened performance with local materials. If the material gradations are not optimum for SCC, a viscosity modifier may be used to improve the quality of the mix. Please consult a local Euclid Chemical Sales Professional for trial mixtures and dosage recommendations.

EUCON 37 is compatible with most admixtures including air-entraining agents, accelerators, most water-reducers, retarders, shrinkage reducers, corrosion inhibitors, viscosity modifiers, and microsilica; however, each material should be added to the concrete separately.

Figure 1: Recommended Dosage of Eucon 37 to achieve flowable concrete (7 - 9"/ 180-230 mm slump)

Initial Slump, inches (mm)	Dosage Range of Eucon 37, oz/cwt (mL/100 kg)
4 (100)	8 - 10 (520 - 650)
3 (75)	10 - 12 (650 - 780)
2 1/2 (65)	12 - 14 (780 - 910)
2 (50)	14 - 16 (910 - 1040)
1 1/2 (40)	16 - 18 (1040 - 1170)

Placement

Concrete treated with EUCON 37 may be placed in the same fashion as conventional concrete.

Formwork

Forms for walls or narrow sections must be watertight, strong and have good bracing. During the "flowing period", when the concrete is at a slump of 7" to 9" (180-230 mm), the concrete will exert a higher pressure at the base of the form than conventional concrete. Formwork for slabs is the same as for conventional concrete.

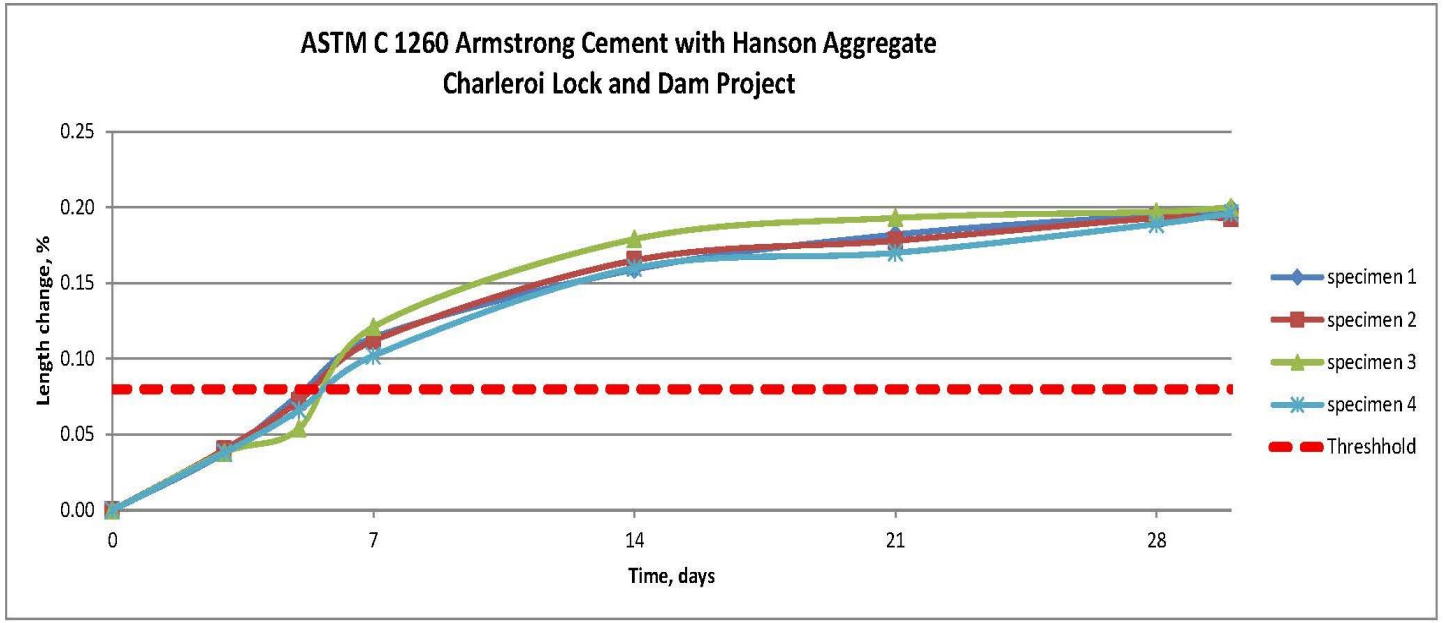
PRECAUTIONS / LIMITATIONS

- Care should be taken to maintain EUCON 37 above freezing; however, freezing and subsequent thawing will not harm the material if thoroughly agitated. Never agitate with air or an air lance.
- Keep concrete from freezing until a minimum strength of 1000 psi (7 MPa) is reached.
- In all cases, consult the Safety Data Sheet before use.

Rev. 2.15

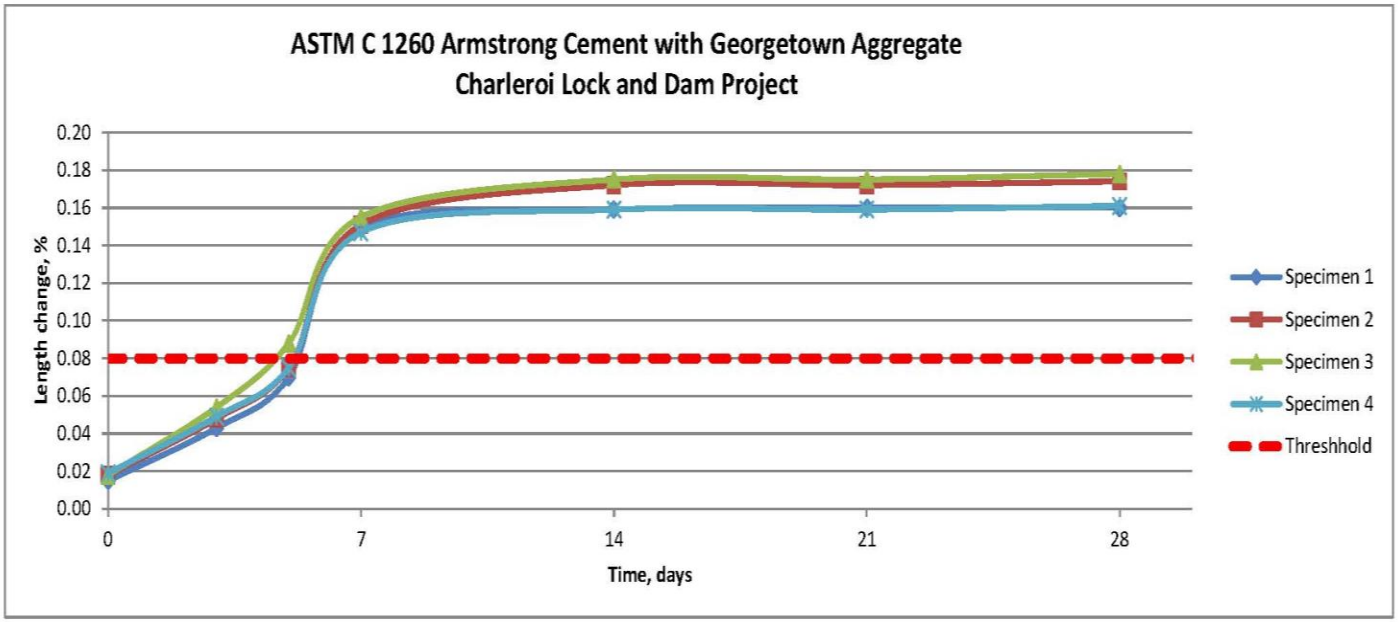
Appendix B: Worksheets for ASTM C1260

Mix:	Hanson Aggregate w/ Armstrong Cement															
Potential Alkali Reactivity of Aggregates, ASTM C 1260																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	4/28/2015		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	4/30/2015		0.0057			0.0052			0.0031			0.0029				
zero read	5/1/2015	0	0.0103		0.0000	0.0097		0.0000	0.0078		0.0000	0.0072		0.0000	0.0000	0.0000
	5/4/2015	3	0.0141	0.0038	0.0380	0.0137	0.0040	0.0400	0.0116	0.0038	0.0380	0.0110	0.0038	0.0380	0.0385	0.0010
	5/6/2015	5	0.0179	0.0076	0.0760	0.0169	0.0072	0.0720	0.0132	0.0054	0.0540	0.0138	0.0066	0.0660	0.0670	0.0096
	5/8/2015	7	0.0217	0.0114	0.1140	0.0209	0.0112	0.1120	0.0199	0.0121	0.1210	0.0174	0.0102	0.1020	0.1123	0.0078
	5/15/2015	14	0.0262	0.0159	0.1590	0.0262	0.0165	0.1650	0.0257	0.0179	0.1790	0.0232	0.0160	0.1600	0.1658	0.0092
	5/22/2015	21	0.0285	0.0182	0.1820	0.0275	0.0178	0.1780	0.0271	0.0193	0.1930	0.0242	0.0170	0.1700	0.1808	0.0096
	5/29/2015	28	0.0298	0.0195	0.1950	0.0290	0.0193	0.1930	0.0275	0.0197	0.1970	0.0261	0.0189	0.1890	0.1935	0.0034
	5/31/2015	30	0.0302	0.0199	0.1990	0.0290	0.0193	0.1930	0.0278	0.0200	0.2000	0.0268	0.0196	0.1960	0.1970	0.0032
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.																



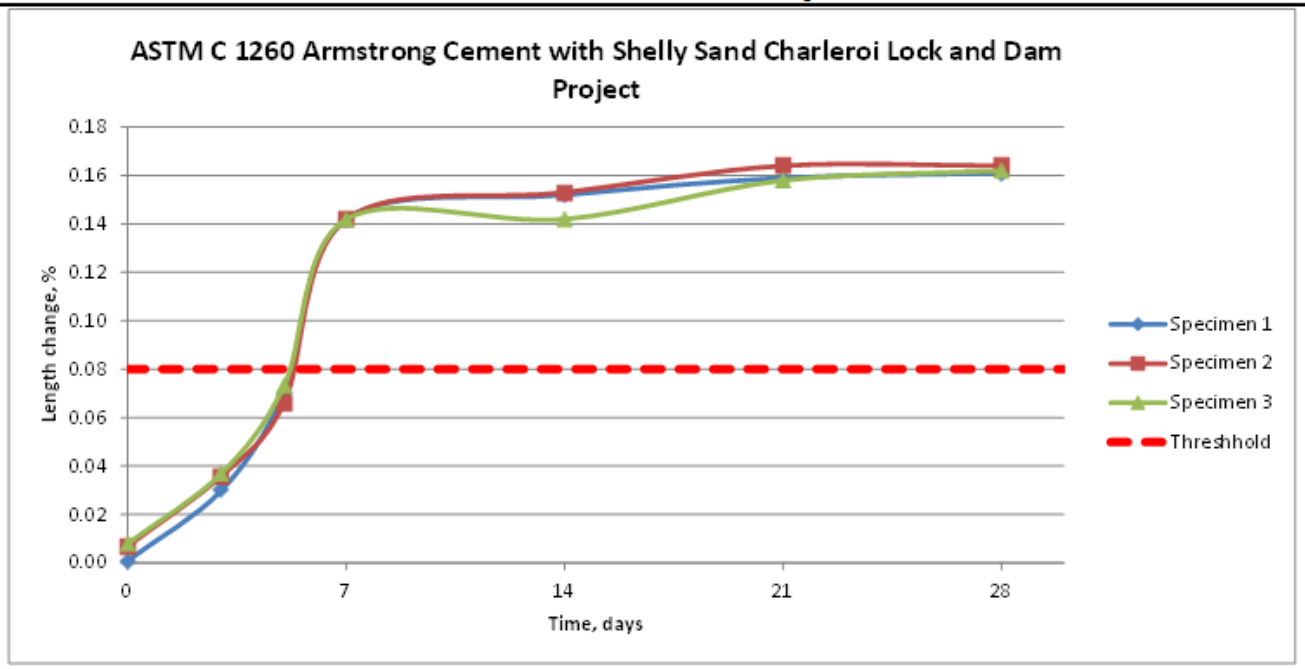
Mix:	Georgetown Aggregate w/ Armstrong Cement															
Potential Alkali Reactivity of Aggregates, ASTM C 1260																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	4/21/2015		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	4/23/2015		-0.0014			0.0005			-0.0032			0.0054				
zero read	4/24/2015	0	0.0057		0.0000	0.0076		0.0000	0.0039		0.0000	0.0122		0.0000	0.0000	0.0000
	4/27/2015	3	0.0072	0.0015	0.0150	0.0094	0.0018	0.0180	0.0057	0.0018	0.0180	0.0141	0.0019	0.0190	0.0175	0.0017
	4/29/2015	5	0.0100	0.0043	0.0430	0.0124	0.0048	0.0480	0.0093	0.0054	0.0540	0.0171	0.0049	0.0490	0.0485	0.0045
	5/1/2015	7	0.0127	0.0070	0.0700	0.0151	0.0075	0.0750	0.0127	0.0088	0.0880	0.0197	0.0075	0.0750	0.0770	0.0077
	5/8/2015	14	0.0206	0.0149	0.1490	0.0227	0.0151	0.1510	0.0194	0.0155	0.1550	0.0269	0.0147	0.1470	0.1505	0.0034
	5/15/2015	21	0.0216	0.0159	0.1590	0.0248	0.0172	0.1720	0.0214	0.0175	0.1750	0.0281	0.0159	0.1590	0.1663	0.0085
	5/22/2015	28	0.0217	0.0160	0.1600	0.0248	0.0172	0.1720	0.0214	0.0175	0.1750	0.0281	0.0159	0.1590	0.1665	0.0082
	5/24/2015	30	0.0217	0.0160	0.1600	0.0250	0.0174	0.1740	0.0217	0.0178	0.1780	0.0283	0.0161	0.1610	0.1683	0.0091

Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.



Mix:	Shelly Sand w/ Armstrong Cement												
Potential Alkali Reactivity of Aggregates, ASTM C 1260													
	Date		Specimen 1			Specimen 2			Specimen 3			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/18/2015		-	-	-	-	-	-	-	-	-	-	-
Initial	11/19/2015		0.0004			-0.1120			0.0029				
zero read	11/20/2015	0	0.0091		0.0000	-0.0024		0.0000	0.0118		0.0000	0.0000	0.0000
	11/23/2015	3	0.0092	0.0001	0.0010	-0.0017	0.0007	0.0070	0.0126	0.0008	0.0080	0.0053	0.0038
	11/25/2015	5	0.0121	0.0030	0.0300	0.0012	0.0036	0.0360	0.0155	0.0037	0.0370	0.0343	0.0038
	11/27/2015	7	0.0161	0.0070	0.0700	0.0042	0.0066	0.0660	0.0191	0.0073	0.0730	0.0697	0.0035
	12/4/2015	14	0.0233	0.0142	0.1420	0.0118	0.0142	0.1420	0.0260	0.0142	0.1420	0.1420	0.0000
	12/11/2015	21	0.0243	0.0152	0.1520	0.0129	0.0153	0.1530	0.0260	0.0142	0.1420	0.1490	0.0061
	12/18/2015	28	0.0250	0.0159	0.1590	0.0140	0.0164	0.1640	0.0276	0.0158	0.1580	0.1603	0.0032
	12/20/2015	30	0.0252	0.0161	0.1610	0.0140	0.0164	0.1640	0.0280	0.0162	0.1620	0.1623	0.0015

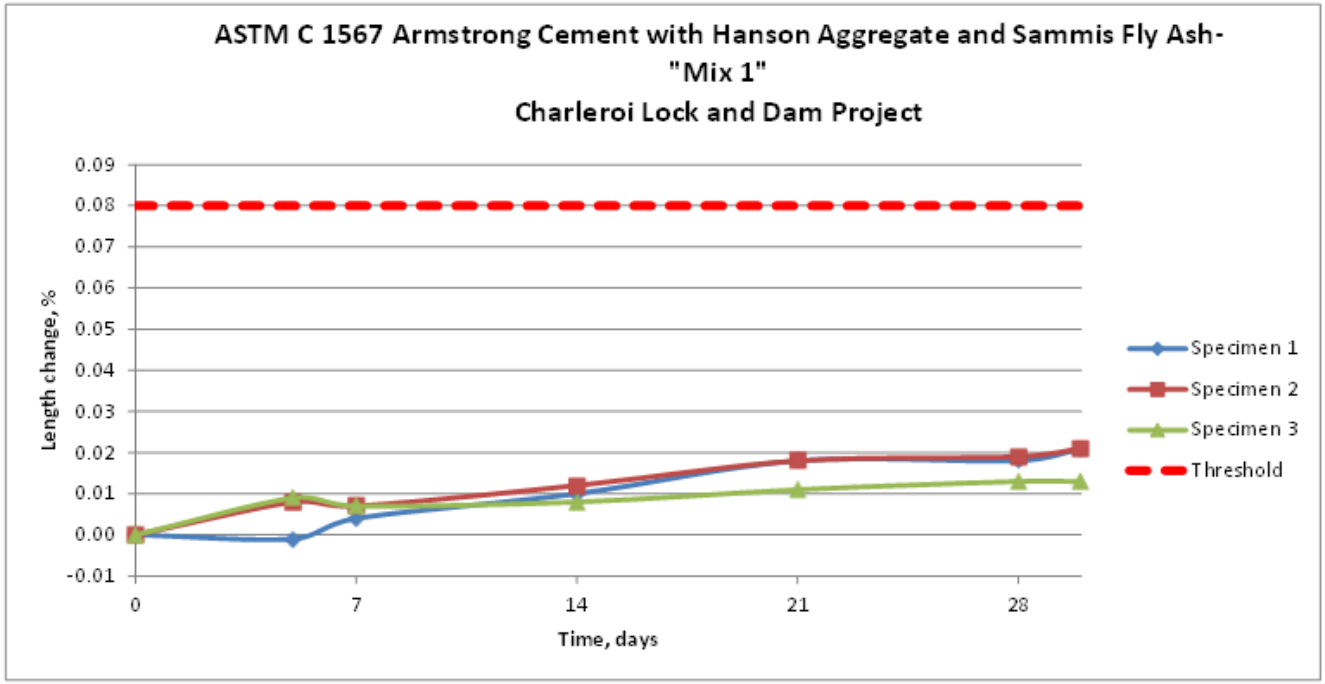
* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.



Appendix C: Worksheets for ASTM C1567

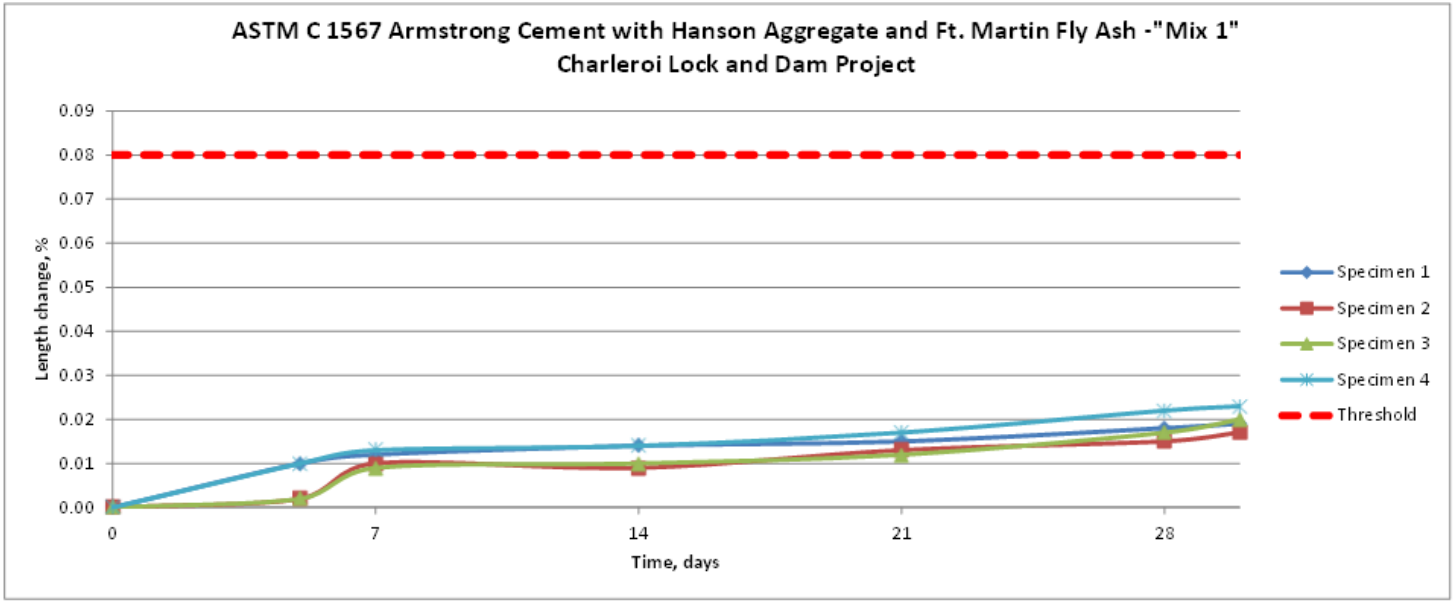
Mix:	Mix 1 with Hanson Aggregate and Sammis Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
	Date		Specimen 1			Specimen 2			Specimen 3			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	5/5/2015		-	-	-	-	-	-	-	-	-	-	-
Initial	5/7/2015		0.0031			0.0020			0.0058				
zero read	5/8/2015	0	0.0076		0.0000	0.0066		0.0000	0.0097		0.0000	0.0000	0.0000
	5/13/2015	5	0.0075	-0.0001	-0.0010	0.0074	0.0008	0.0080	0.0106	0.0009	0.0090	0.0053	0.0055
	5/15/2015	7	0.0080	0.0004	0.0040	0.0073	0.0007	0.0070	0.0104	0.0007	0.0070	0.0060	0.0017
	5/22/2015	14	0.0086	0.0010	0.0100	0.0078	0.0012	0.0120	0.0105	0.0008	0.0080	0.0100	0.0020
	5/29/2015	21	0.0094	0.0018	0.0180	0.0084	0.0018	0.0180	0.0108	0.0011	0.0110	0.0157	0.0040
	6/5/2015	28	0.0094	0.0018	0.0180	0.0085	0.0019	0.0190	0.0110	0.0013	0.0130	0.0167	0.0032
	6/7/2015	30	0.0097	0.0021	0.0210	0.0087	0.0021	0.0210	0.0110	0.0013	0.0130	0.0183	0.0046

Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.

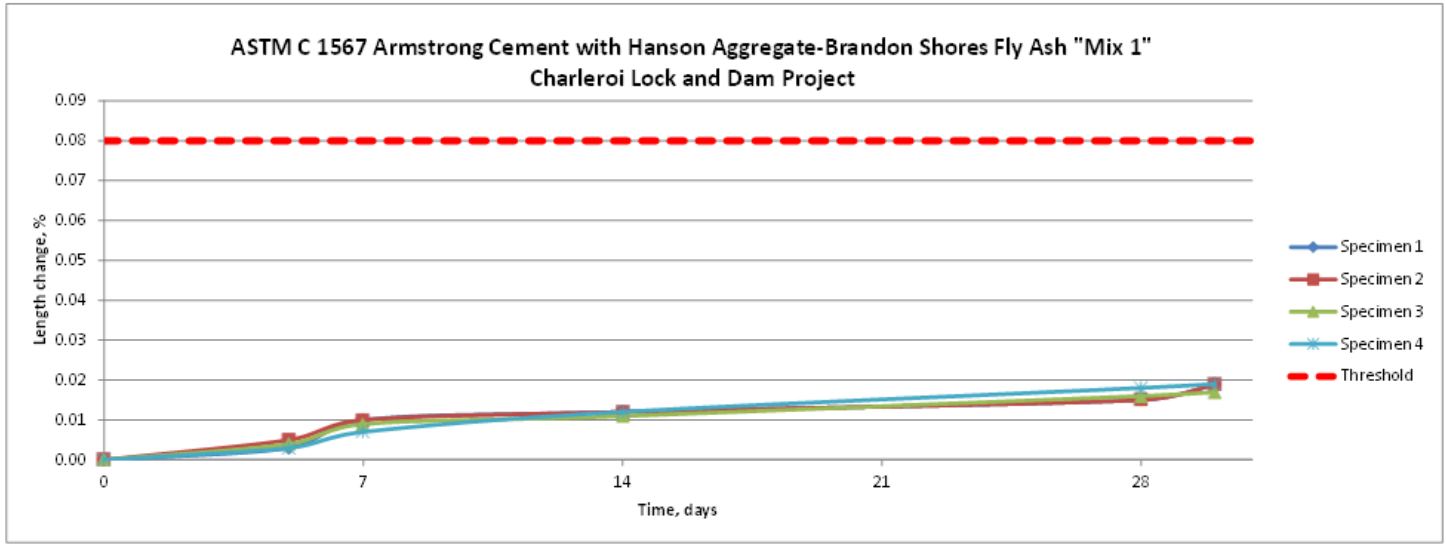


Mix:	Mix 1 with Hanson Aggregate and Ft. Martin Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	5/5/2015		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	5/7/2015		0.0021			-0.0032			0.0069			0.0018				
zero read	5/8/2015	0	0.0066		0.0000	0.0017		0.0000	0.0118		0.0000	0.0053		0.0000	0.0000	0.0000
	5/13/2015	5	0.0076	0.0010	0.0100	0.0019	0.0002	0.0020	0.0120	0.0002	0.0020	0.0063	0.0010	0.0100	0.0060	0.0046
	5/15/2015	7	0.0078	0.0012	0.0120	0.0027	0.0010	0.0100	0.0127	0.0009	0.0090	0.0066	0.0013	0.0130	0.0110	0.0018
	5/22/2015	14	0.0080	0.0014	0.0140	0.0026	0.0009	0.0090	0.0128	0.0010	0.0100	0.0067	0.0014	0.0140	0.0118	0.0026
	5/29/2015	21	0.0081	0.0015	0.0150	0.0030	0.0013	0.0130	0.0130	0.0012	0.0120	0.0070	0.0017	0.0170	0.0143	0.0022
	6/5/2015	28	0.0084	0.0018	0.0180	0.0032	0.0015	0.0150	0.0135	0.0017	0.0170	0.0075	0.0022	0.0220	0.0180	0.0029
	6/7/2015	30	0.0085	0.0019	0.0190	0.0034	0.0017	0.0170	0.0138	0.0020	0.0200	0.0076	0.0023	0.0230	0.0198	0.0025

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.

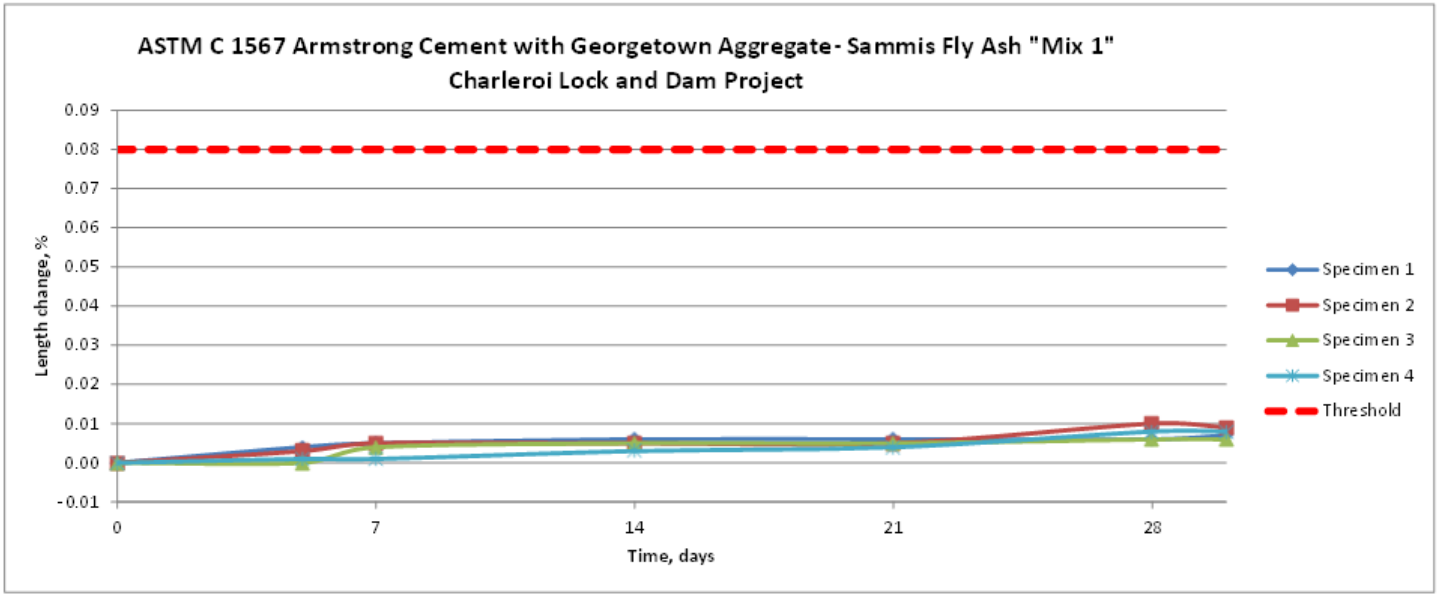


Mix:	Mix 1 with Hanson Sand and Brandon Shores Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	4/3/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	4/5/2018		-0.0109			-0.0079			-0.0043			-0.0051				
zero read	4/6/2018	0	-0.0048		0.0000	-0.0020		0.0000	0.0018		0.0000	0.0008		0.0000	0.0000	0.0000
	4/11/2018	5	-0.0045	0.0003	0.0030	-0.0015	0.0005	0.0050	0.0022	0.0004	0.0040	0.0011	0.0003	0.0030	0.0038	0.0010
	4/13/2018	7	-0.0038	0.0010	0.0100	-0.0010	0.0010	0.0100	0.0027	0.0009	0.0090	0.0015	0.0007	0.0070	0.0090	0.0014
	4/20/2018	14	-0.0036	0.0012	0.0120	-0.0008	0.0012	0.0120	0.0029	0.0011	0.0110	0.0020	0.0012	0.0120	0.0118	0.0005
	5/4/2018	28	-0.0033	0.0015	0.0150	-0.0005	0.0015	0.0150	0.0034	0.0016	0.0160	0.0026	0.0018	0.0180	0.0160	0.0014
	5/6/2018	30	-0.0029	0.0019	0.0190	-0.0001	0.0019	0.0190	0.0035	0.0017	0.0170	0.0027	0.0019	0.0190	0.0185	0.0010
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.																



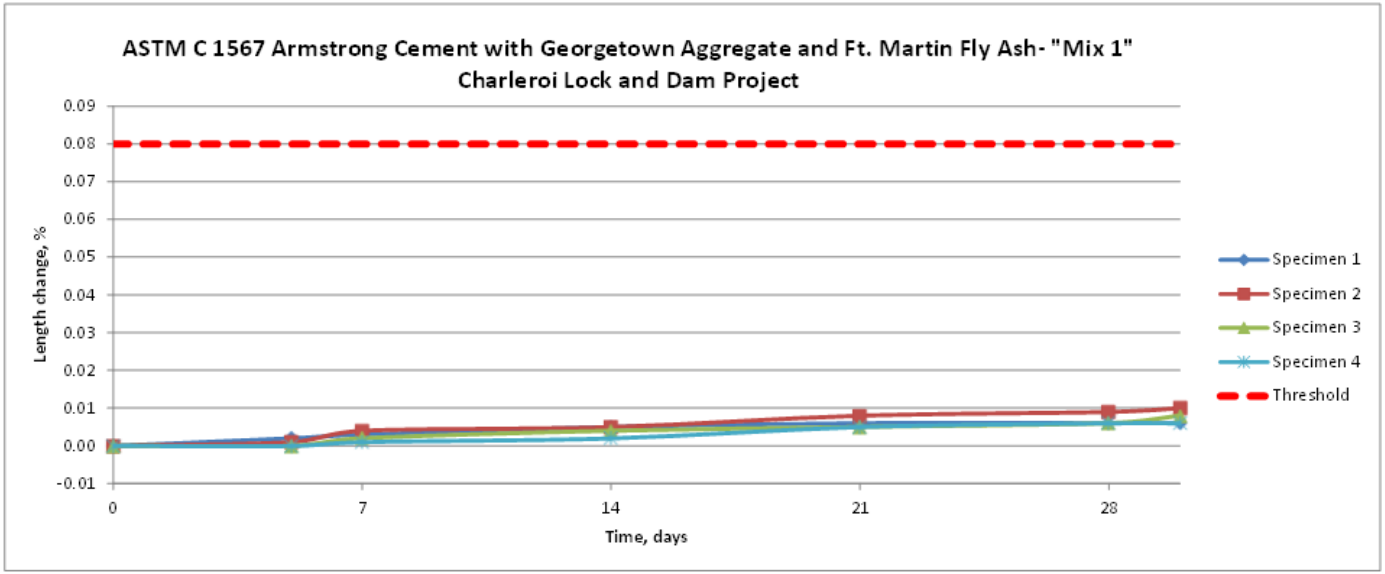
Mix:	Mix 1 with Georgetown Aggregate and Sammis Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	5/5/2015		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	5/7/2015		-0.0002			-0.0057			-0.0071			-0.0016				
zero read	5/8/2015	0	0.0060		0.0000	0.0005		0.0000	-0.0010		0.0000	0.0047		0.0000	0.0000	0.0000
	5/13/2015	5	0.0064	0.0004	0.0040	0.0008	0.0003	0.0030	-0.0010	0.0000	0.0000	0.0048	0.0001	0.0010	0.0020	0.0018
	5/15/2015	7	0.0065	0.0005	0.0050	0.0010	0.0005	0.0050	-0.0006	0.0004	0.0040	0.0048	0.0001	0.0010	0.0038	0.0019
	5/22/2015	14	0.0066	0.0006	0.0060	0.0010	0.0005	0.0050	-0.0005	0.0005	0.0050	0.0050	0.0003	0.0030	0.0048	0.0013
	5/29/2015	21	0.0066	0.0006	0.0060	0.0010	0.0005	0.0050	-0.0005	0.0005	0.0050	0.0051	0.0004	0.0040	0.0050	0.0008
	6/5/2015	28	0.0066	0.0006	0.0060	0.0015	0.0010	0.0100	-0.0004	0.0006	0.0060	0.0055	0.0008	0.0080	0.0075	0.0019
	6/7/2015	30	0.0067	0.0007	0.0070	0.0014	0.0009	0.0090	-0.0004	0.0006	0.0060	0.0055	0.0008	0.0080	0.0075	0.0013

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.



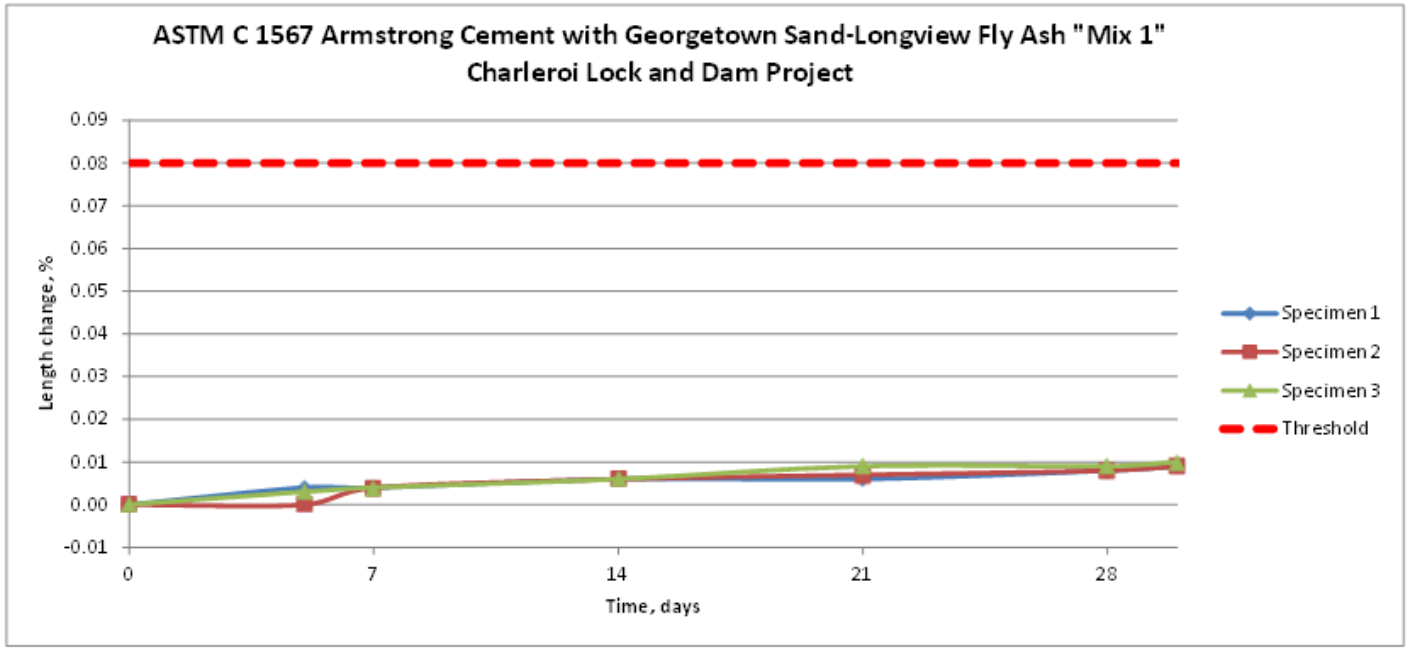
Mix:	Mix 1 with Georgetown Aggregate and Ft. Martin Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	5/5/2015		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	5/7/2015		-0.0160			0.0050			-0.0088			0.0016				
zero read	5/8/2015	0	-0.0102		0.0000	0.0105		0.0000	0.0020		0.0000	0.0080		0.0000	0.0000	0.0000
	5/13/2015	5	-0.0100	0.0002	0.0020	0.0106	0.0001	0.0010	0.0020	0.0000	0.0000	0.0080	0.0000	0.0000	0.0008	0.0010
	5/15/2015	7	-0.0099	0.0003	0.0030	0.0109	0.0004	0.0040	0.0022	0.0002	0.0020	0.0081	0.0001	0.0010	0.0025	0.0013
	5/22/2015	14	-0.0097	0.0005	0.0050	0.0110	0.0005	0.0050	0.0024	0.0004	0.0040	0.0082	0.0002	0.0020	0.0040	0.0014
	5/29/2015	21	-0.0096	0.0006	0.0060	0.0113	0.0008	0.0080	0.0025	0.0005	0.0050	0.0085	0.0005	0.0050	0.0060	0.0014
	6/5/2015	28	-0.0096	0.0006	0.0060	0.0114	0.0009	0.0090	0.0026	0.0006	0.0060	0.0086	0.0006	0.0060	0.0068	0.0015
	6/7/2015	30	-0.0096	0.0006	0.0060	0.0115	0.0010	0.0100	0.0028	0.0008	0.0080	0.0086	0.0006	0.0060	0.0075	0.0019

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.

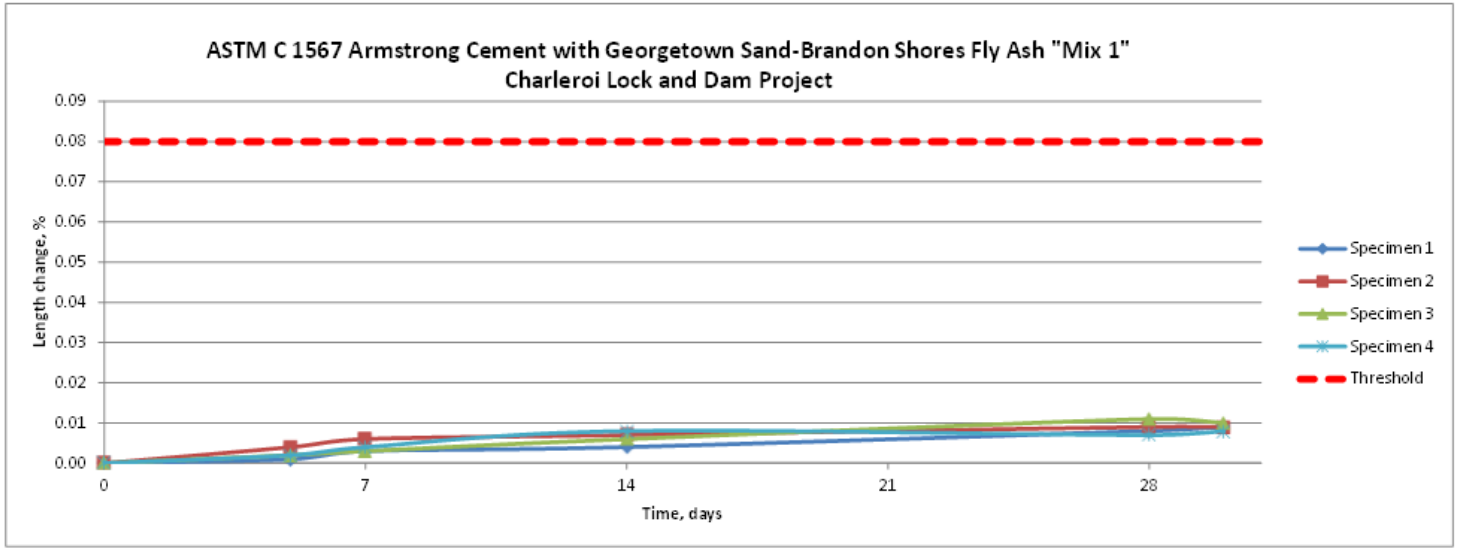


Mix ID:	Mix 1 with Georgetown Sand and Longview Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
			Specimen 1			Specimen 2			Specimen 3			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/14/2017		-	-	-	-	-	-	-	-	-	-	-
Initial	11/16/2017		-0.0091			-0.0127			-0.0086				
zero read	11/17/2017	0	-0.0025		0.0000	-0.0058		0.0000	-0.0015		0.0000	0.0000	0.0000
	11/22/2017	5	-0.0021	0.0004	0.0040	-0.0058	0.0000	0.0000	-0.0012	0.0003	0.0030	0.0023	0.0021
	11/24/2017	7	-0.0021	0.0004	0.0040	-0.0054	0.0004	0.0040	-0.0011	0.0004	0.0040	0.0040	0.0000
	12/1/2017	14	-0.0019	0.0006	0.0060	-0.0052	0.0006	0.0060	-0.0009	0.0006	0.0060	0.0060	0.0000
	12/8/2017	21	-0.0019	0.0006	0.0060	-0.0051	0.0007	0.0070	-0.0006	0.0009	0.0090	0.0073	0.0015
	12/15/2017	28	-0.0017	0.0008	0.0080	-0.0050	0.0008	0.0080	-0.0006	0.0009	0.0090	0.0083	0.0006
	12/17/2017	30	-0.0016	0.0009	0.0090	-0.0049	0.0009	0.0090	-0.0005	0.0010	0.0100	0.0093	0.0006

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.

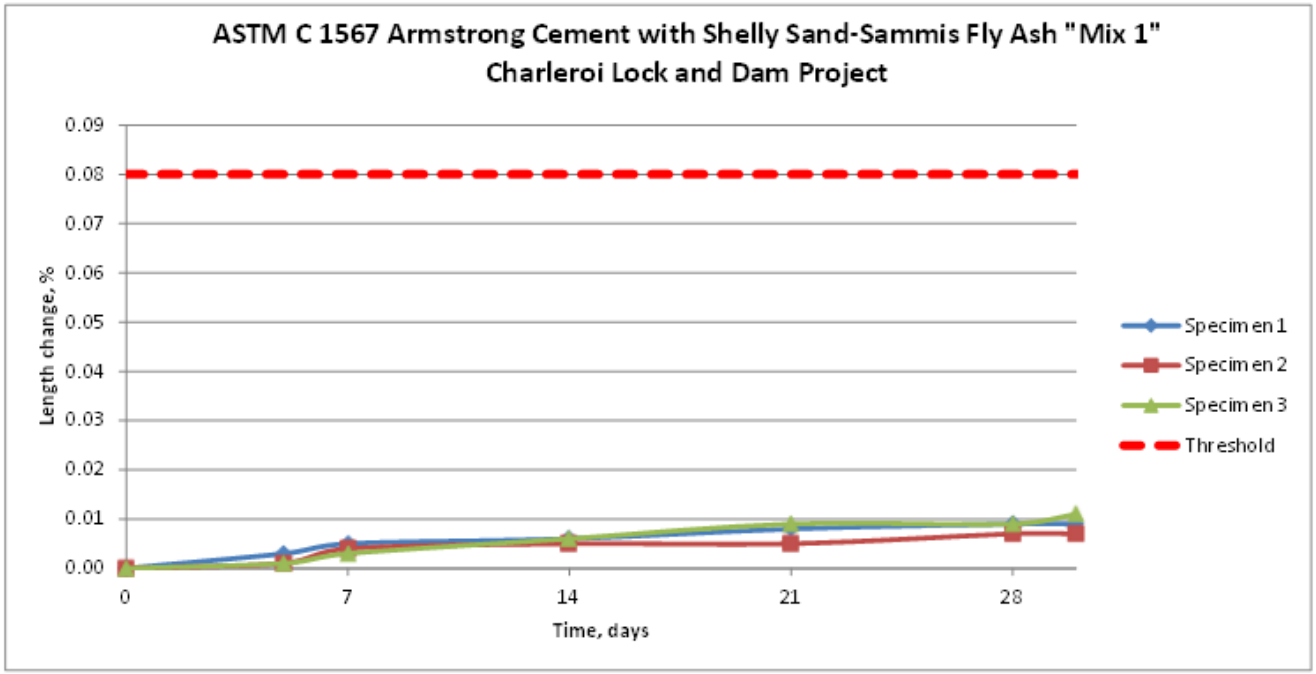


Mix:	Mix 1 with Georgetown Sand and Brandon Shores Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	4/3/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	4/5/2018		-0.0124			-0.0086			-0.0092			-0.0103				
zero read	4/6/2018	0	-0.0061		0.0000	-0.0016		0.0000	-0.0023		0.0000	-0.0032		0.0000	0.0000	0.0000
	4/11/2018	5	-0.0060	0.0001	0.0010	-0.0012	0.0004	0.0040	-0.0021	0.0002	0.0020	-0.0030	0.0002	0.0020	0.0023	0.0013
	4/13/2018	7	-0.0058	0.0003	0.0030	-0.0010	0.0006	0.0060	-0.0020	0.0003	0.0030	-0.0028	0.0004	0.0040	0.0040	0.0014
	4/20/2018	14	-0.0057	0.0004	0.0040	-0.0009	0.0007	0.0070	-0.0017	0.0006	0.0060	-0.0024	0.0008	0.0080	0.0063	0.0017
	5/4/2018	28	-0.0053	0.0008	0.0080	-0.0007	0.0009	0.0090	-0.0012	0.0011	0.0110	-0.0025	0.0007	0.0070	0.0088	0.0017
	5/6/2018	30	-0.0052	0.0009	0.0090	-0.0007	0.0009	0.0090	-0.0013	0.0010	0.0100	-0.0024	0.0008	0.0080	0.0090	0.0008
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.																



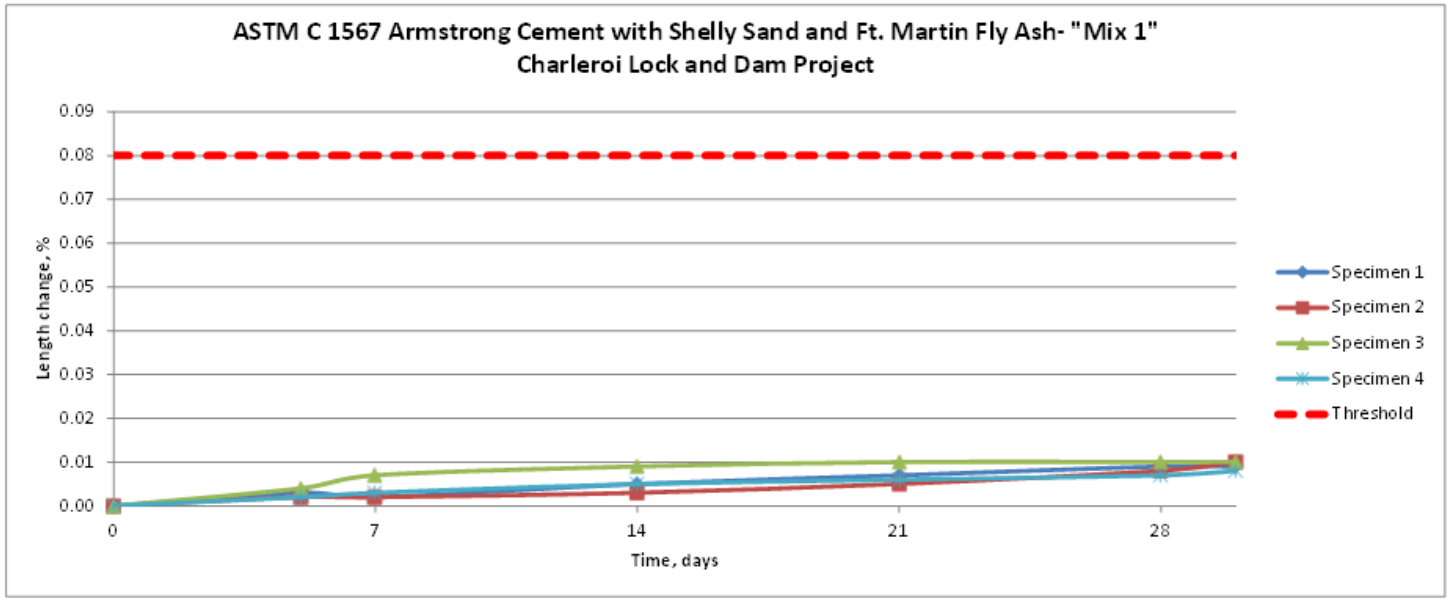
Mix:	Mix 1 with Shelly Sand and Sammis Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
	Date		Specimen 1			Specimen 2			Specimen 3			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/17/2015		-	-	-	-	-	-	-	-	-	-	-
Initial	11/19/2015		-0.0147			-0.0033			-0.0029				
zero read	11/20/2015	0	-0.0093		0.0000	0.0025		0.0000	0.0031		0.0000	0.0000	0.0000
	11/25/2015	5	-0.0090	0.0003	0.0030	0.0026	0.0001	0.0010	0.0032	0.0001	0.0010	0.0017	0.0012
	11/27/2015	7	-0.0088	0.0005	0.0050	0.0029	0.0004	0.0040	0.0034	0.0003	0.0030	0.0040	0.0010
	12/4/2015	14	-0.0087	0.0006	0.0060	0.0030	0.0005	0.0050	0.0037	0.0006	0.0060	0.0057	0.0006
	12/11/2015	21	-0.0085	0.0008	0.0080	0.0030	0.0005	0.0050	0.0040	0.0009	0.0090	0.0073	0.0021
	12/18/2015	28	-0.0084	0.0009	0.0090	0.0032	0.0007	0.0070	0.0040	0.0009	0.0090	0.0083	0.0012
	12/20/2015	30	-0.0084	0.0009	0.0090	0.0032	0.0007	0.0070	0.0042	0.0011	0.0110	0.0090	0.0020

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.



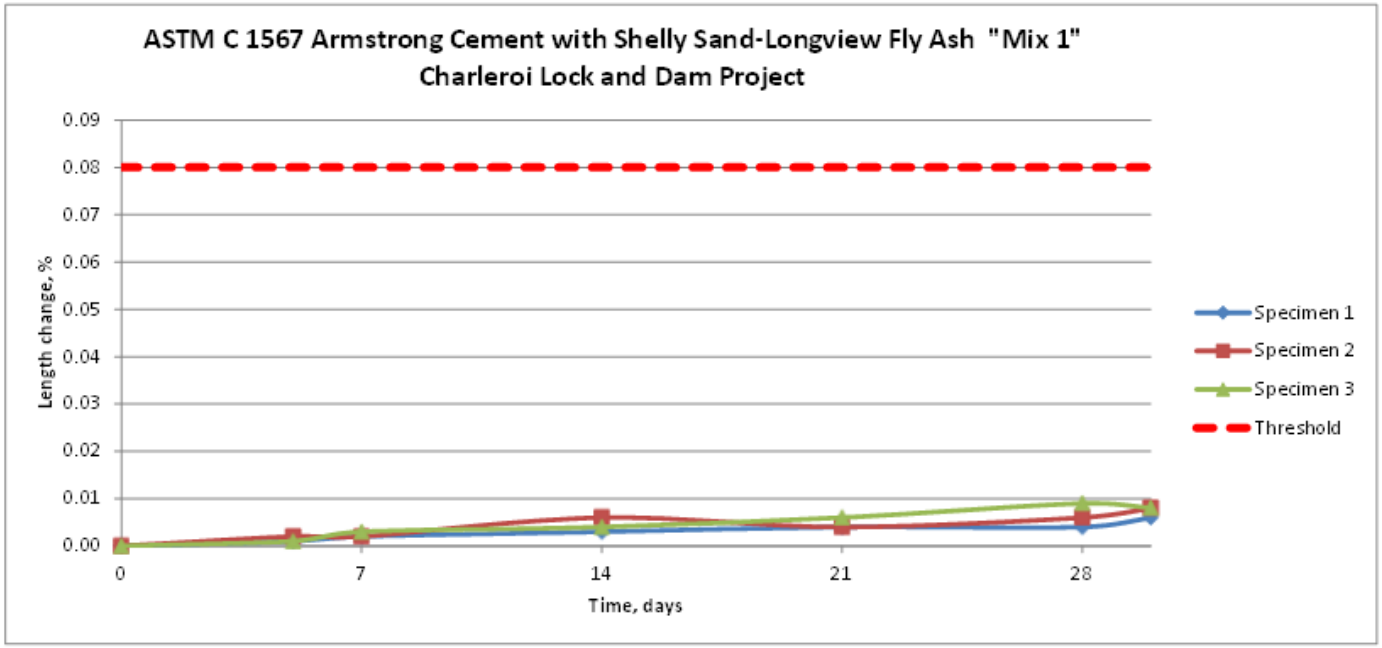
Mix:	Mix 1 with Shelly Sand and Ft. Martin Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/17/2015		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	11/19/2015		-0.0086			-0.0096			-0.0062			-0.0070				
zero read	11/20/2015	0	-0.0031		0.0000	-0.0036		0.0000	-0.0002		0.0000	-0.0005		0.0000	0.0000	0.0000
	11/25/2015	5	-0.0028	0.0003	0.0030	-0.0034	0.0002	0.0020	0.0002	0.0004	0.0040	-0.0003	0.0002	0.0020	0.0028	0.0010
	11/27/2015	7	-0.0029	0.0002	0.0020	-0.0034	0.0002	0.0020	0.0005	0.0007	0.0070	-0.0002	0.0003	0.0030	0.0035	0.0024
	12/4/2015	14	-0.0026	0.0005	0.0050	-0.0033	0.0003	0.0030	0.0007	0.0009	0.0090	0.0000	0.0005	0.0050	0.0055	0.0025
	12/11/2015	21	-0.0024	0.0007	0.0070	-0.0031	0.0005	0.0050	0.0008	0.0010	0.0100	0.0001	0.0006	0.0060	0.0070	0.0022
	12/18/2015	28	-0.0022	0.0009	0.0090	-0.0028	0.0008	0.0080	0.0008	0.0010	0.0100	0.0002	0.0007	0.0070	0.0085	0.0013
	12/20/2015	30	-0.0022	0.0009	0.0090	-0.0026	0.0010	0.0100	0.0008	0.0010	0.0100	0.0003	0.0008	0.0080	0.0093	0.0010

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.



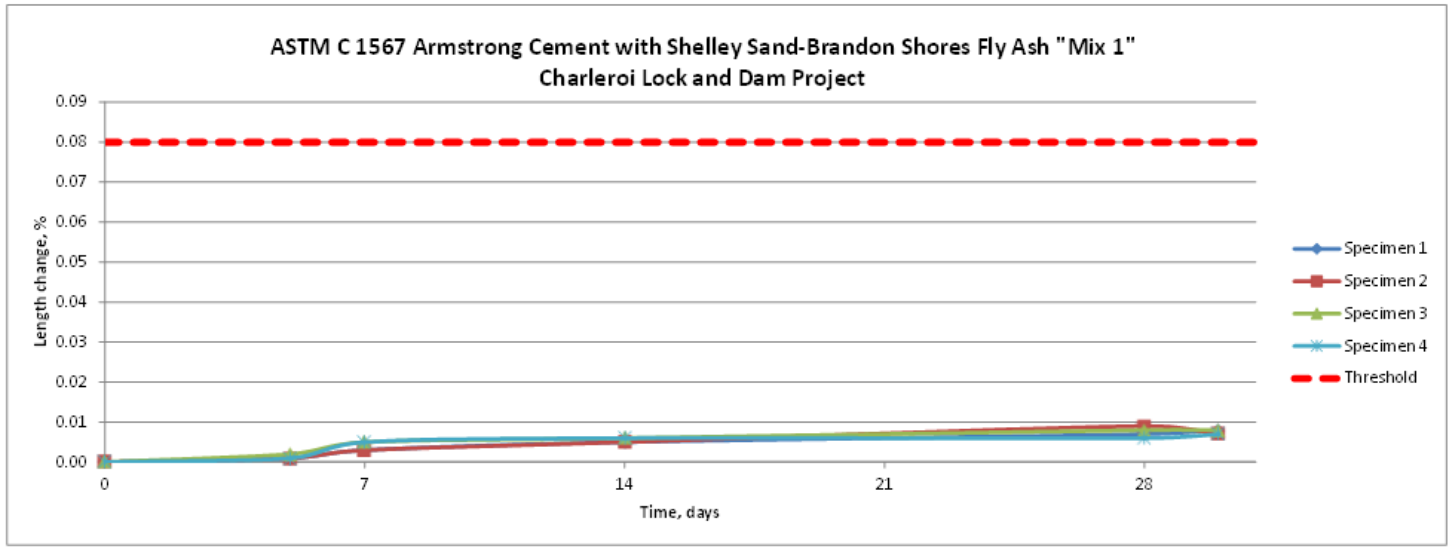
Mix:	Mix 1 with Shelley Sand and Longview Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
			Specimen 1			Specimen 2			Specimen 3			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/14/2017		-	-	-	-	-	-	-	-	-	-	-
Initial	11/16/2017		-0.0103			-0.0122			-0.0054				
zero read	11/17/2017	0	-0.0031		0.0000	-0.0050		0.0000	0.0016		0.0000	0.0000	0.0000
	11/22/2017	5	-0.0030	0.0001	0.0010	-0.0048	0.0002	0.0020	0.0017	0.0001	0.0010	0.0013	0.0006
	11/24/2017	7	-0.0029	0.0002	0.0020	-0.0048	0.0002	0.0020	0.0019	0.0003	0.0030	0.0023	0.0006
	12/1/2017	14	-0.0028	0.0003	0.0030	-0.0044	0.0006	0.0060	0.0020	0.0004	0.0040	0.0043	0.0015
	12/8/2017	21	-0.0027	0.0004	0.0040	-0.0046	0.0004	0.0040	0.0022	0.0006	0.0060	0.0047	0.0012
	12/15/2017	28	-0.0027	0.0004	0.0040	-0.0044	0.0006	0.0060	0.0025	0.0009	0.0090	0.0063	0.0025
	12/17/2017	30	-0.0025	0.0006	0.0060	-0.0042	0.0008	0.0080	0.0024	0.0008	0.0080	0.0073	0.0012

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.



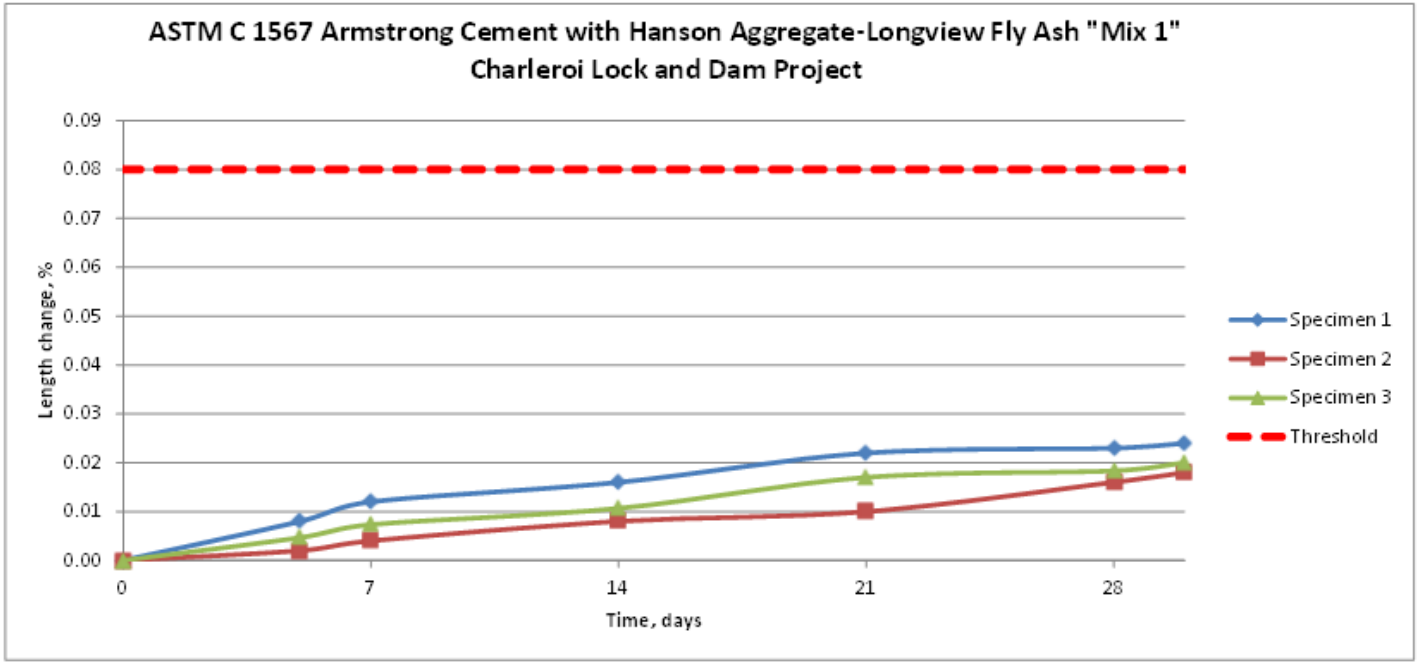
Mix:	Mix 1 with Shelley Sand and Brandon Shores Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	4/3/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	4/5/2018		-0.0090			-0.0109			-0.0090			-0.0098				
zero read	4/6/2018	0	-0.0017		0.0000	-0.0036		0.0000	-0.0017		0.0000	-0.0023		0.0000	0.0000	0.0000
	4/11/2018	5	-0.0016	0.0001	0.0010	-0.0035	0.0001	0.0010	-0.0015	0.0002	0.0020	-0.0022	0.0001	0.0010	0.0013	0.0005
	4/13/2018	7	-0.0014	0.0003	0.0030	-0.0033	0.0003	0.0030	-0.0012	0.0005	0.0050	-0.0018	0.0005	0.0050	0.0040	0.0012
	4/20/2018	14	-0.0012	0.0005	0.0050	-0.0031	0.0005	0.0050	-0.0011	0.0006	0.0060	-0.0017	0.0006	0.0060	0.0055	0.0006
	5/4/2018	28	-0.0010	0.0007	0.0070	-0.0027	0.0009	0.0090	-0.0009	0.0008	0.0080	-0.0017	0.0006	0.0060	0.0075	0.0013
	5/6/2018	30	-0.0009	0.0008	0.0080	-0.0029	0.0007	0.0070	-0.0009	0.0008	0.0080	-0.0016	0.0007	0.0070	0.0075	0.0006

Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.



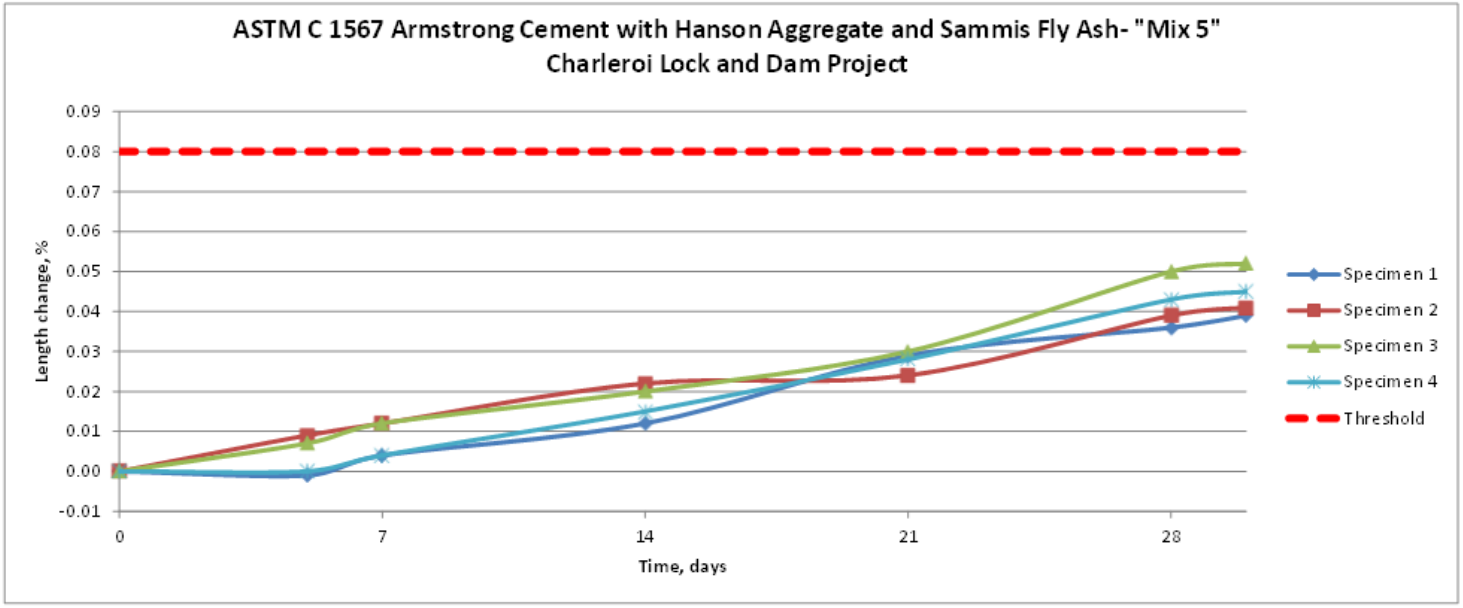
Mix:	Mix 1 with Hanson Aggregate and Longview Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
			Specimen 1			Specimen 2			Specimen 3			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/14/2017		-	-	-	-	-	-	-	-	-	-	-
Initial	11/16/2017		0.0024			-0.0135			-0.0037				
zero read	11/17/2017	0	0.0073		0.0000	-0.0078		0.0000	-0.0284		0.0000	0.0000	0.0000
	11/22/2017	5	0.0081	0.0008	0.0080	-0.0076	0.0002	0.0020	-0.0280	0.0004	0.0040	0.0047	0.0034
	11/24/2017	7	0.0085	0.0012	0.0120	-0.0074	0.0004	0.0040	-0.0278	0.0006	0.0060	0.0073	0.0050
	12/1/2017	14	0.0089	0.0016	0.0160	-0.0070	0.0008	0.0080	-0.0276	0.0008	0.0080	0.0107	0.0065
	12/8/2017	21	0.0095	0.0022	0.0220	-0.0068	0.0010	0.0100	-0.0265	0.0019	0.0190	0.0170	0.0099
	12/15/2017	28	0.0096	0.0023	0.0230	-0.0062	0.0016	0.0160	-0.0268	0.0016	0.0160	0.0183	0.0097
	12/17/2017	30	0.0097	0.0024	0.0240	-0.0060	0.0018	0.0180	-0.0266	0.0018	0.0180	0.0200	0.0104

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.



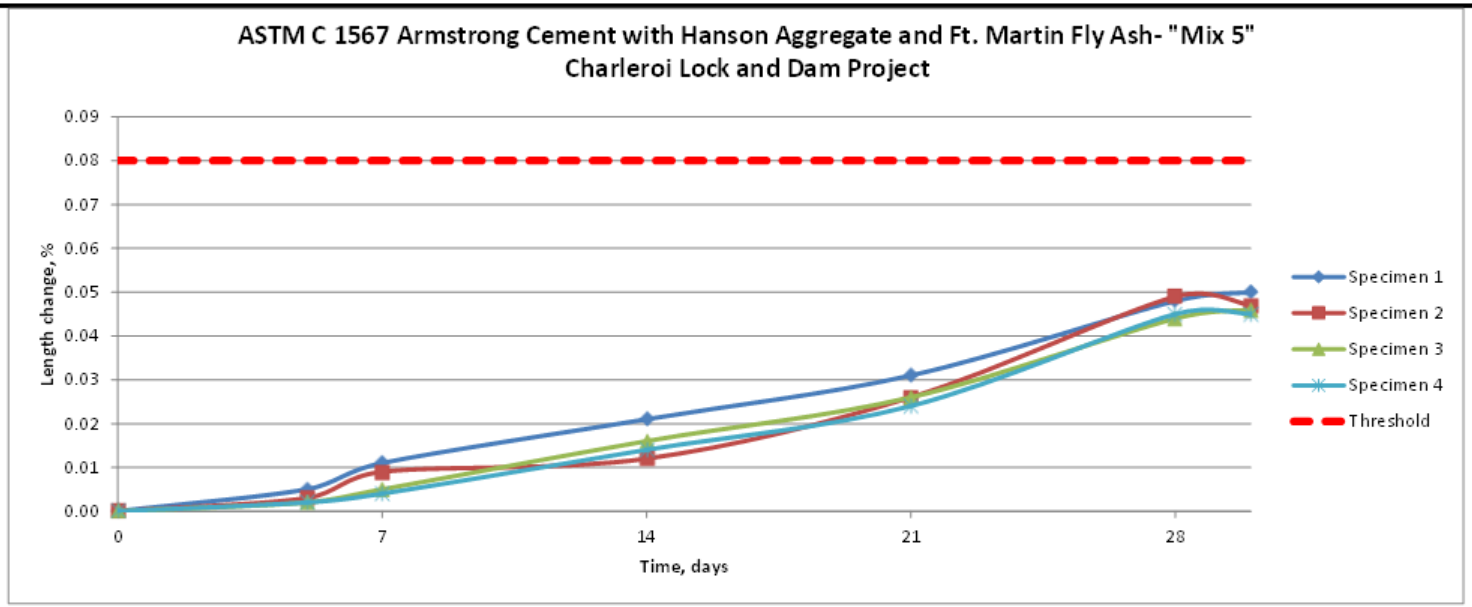
Mix:	Mix 5 with Hanson Aggregate and Sammis Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	5/5/2015		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	5/7/2015		0.0023			0.0018			0.0059			-0.0236				
zero read	5/8/2015	0	0.0086		0.0000	0.0070		0.0000	0.0110		0.0000	-0.0177		0.0000	0.0000	0.0000
	5/13/2015	5	0.0085	-0.0001	-0.0010	0.0079	0.0009	0.0090	0.0117	0.0007	0.0070	-0.0177	0.0000	0.0000	0.0038	0.0050
	5/15/2015	7	0.0090	0.0004	0.0040	0.0082	0.0012	0.0120	0.0122	0.0012	0.0120	-0.0173	0.0004	0.0040	0.0080	0.0046
	5/22/2015	14	0.0098	0.0012	0.0120	0.0092	0.0022	0.0220	0.0130	0.0020	0.0200	-0.0162	0.0015	0.0150	0.0173	0.0046
	5/29/2015	21	0.0115	0.0029	0.0290	0.0094	0.0024	0.0240	0.0140	0.0030	0.0300	-0.0149	0.0028	0.0280	0.0278	0.0026
	6/5/2015	28	0.0122	0.0036	0.0360	0.0109	0.0039	0.0390	0.0160	0.0050	0.0500	-0.0134	0.0043	0.0430	0.0420	0.0061
	6/7/2015	30	0.0125	0.0039	0.0390	0.0111	0.0041	0.0410	0.0162	0.0052	0.0520	-0.0132	0.0045	0.0450	0.0443	0.0057

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.



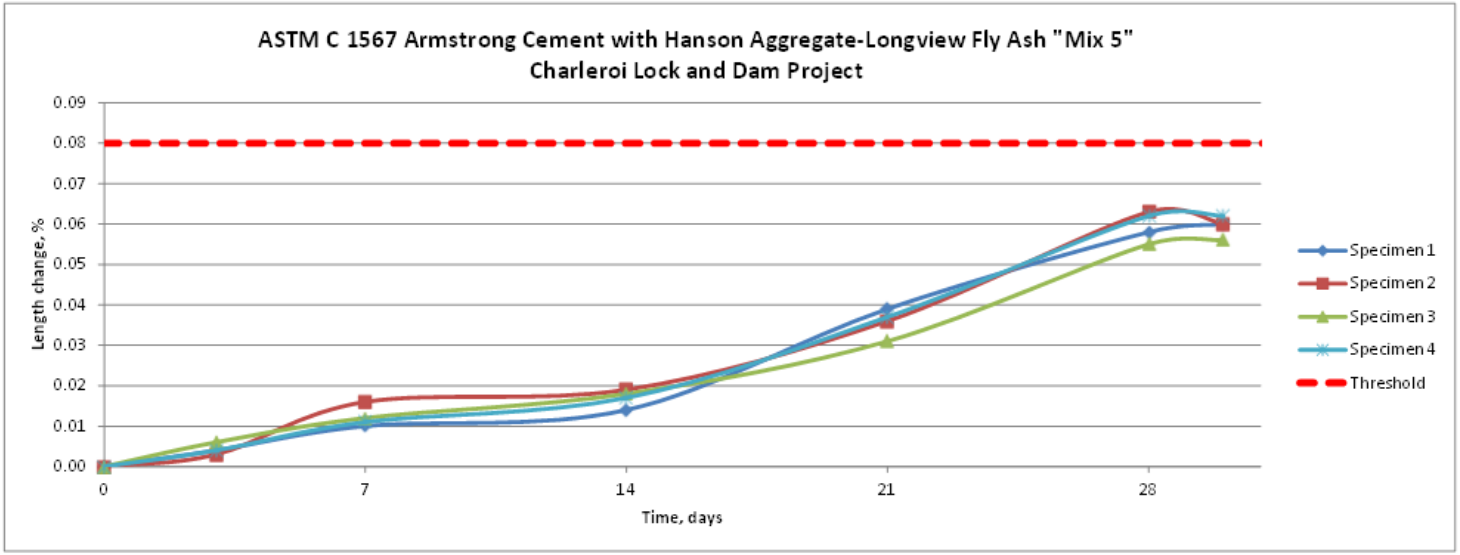
Mix:	Mix 5 with Hanson Aggregate and Ft. Martin Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	4/28/2015		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	4/30/2015		-0.0068			-0.0131			0.0313			-0.0166				
zero read	5/1/2015	0	-0.0008		0.0000	-0.0074		0.0000	0.0371		0.0000	-0.0108		0.0000	0.0000	0.0000
	5/6/2015	5	-0.0003	0.0005	0.0050	-0.0071	0.0003	0.0030	0.0373	0.0002	0.0020	-0.0106	0.0002	0.0020	0.0030	0.0014
	5/8/2015	7	0.0003	0.0011	0.0110	-0.0065	0.0009	0.0090	0.0376	0.0005	0.0050	-0.0104	0.0004	0.0040	0.0073	0.0033
	5/15/2015	14	0.0013	0.0021	0.0210	-0.0062	0.0012	0.0120	0.0387	0.0016	0.0160	-0.0094	0.0014	0.0140	0.0158	0.0039
	5/22/2015	21	0.0023	0.0031	0.0310	-0.0048	0.0026	0.0260	0.0397	0.0026	0.0260	-0.0084	0.0024	0.0240	0.0268	0.0030
	5/29/2015	28	0.0040	0.0048	0.0480	-0.0025	0.0049	0.0490	0.0415	0.0044	0.0440	-0.0063	0.0045	0.0450	0.0465	0.0024
	5/31/2015	30	0.0042	0.0050	0.0500	-0.0027	0.0047	0.0470	0.0417	0.0046	0.0460	-0.0063	0.0045	0.0450	0.0470	0.0022

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.



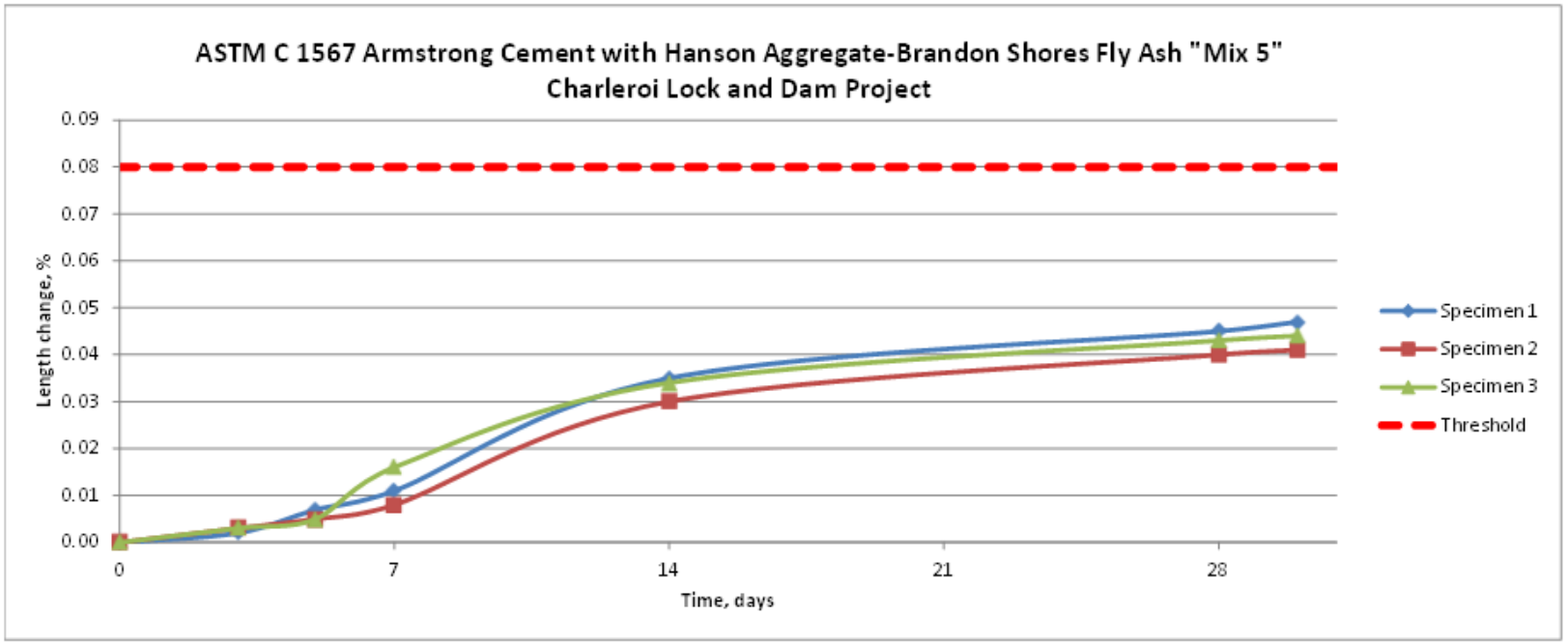
Mix:	Mix 5 with Hanson Aggregate and Longview Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/MYr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/28/2017		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	11/30/2017		-0.0182			-0.0062			-0.0048			-0.0092				
zero read	12/1/2017	0	-0.0125		0.0000	-0.0006		0.0000	0.0009		0.0000	-0.0037		0.0000	0.0000	0.0000
	12/4/2017	3	-0.0121	0.0004	0.0040	-0.0003	0.0003	0.0030	0.0015	0.0006	0.0060	-0.0033	0.0004	0.0040	0.0043	0.0013
	12/8/2017	7	-0.0115	0.0010	0.0100	0.0010	0.0016	0.0160	0.0021	0.0012	0.0120	-0.0026	0.0011	0.0110	0.0123	0.0026
	12/15/2017	14	-0.0111	0.0014	0.0140	0.0013	0.0019	0.0190	0.0027	0.0018	0.0180	-0.0020	0.0017	0.0170	0.0170	0.0022
	12/22/2017	21	-0.0086	0.0039	0.0390	0.0030	0.0036	0.0360	0.0040	0.0031	0.0310	0.0000	0.0037	0.0370	0.0358	0.0034
	12/29/2017	28	-0.0067	0.0058	0.0580	0.0057	0.0063	0.0630	0.0064	0.0055	0.0550	0.0025	0.0062	0.0620	0.0595	0.0037
	12/31/2017	30	-0.0065	0.0060	0.0600	0.0054	0.0060	0.0600	0.0065	0.0056	0.0560	0.0025	0.0062	0.0620	0.0595	0.0025

Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.



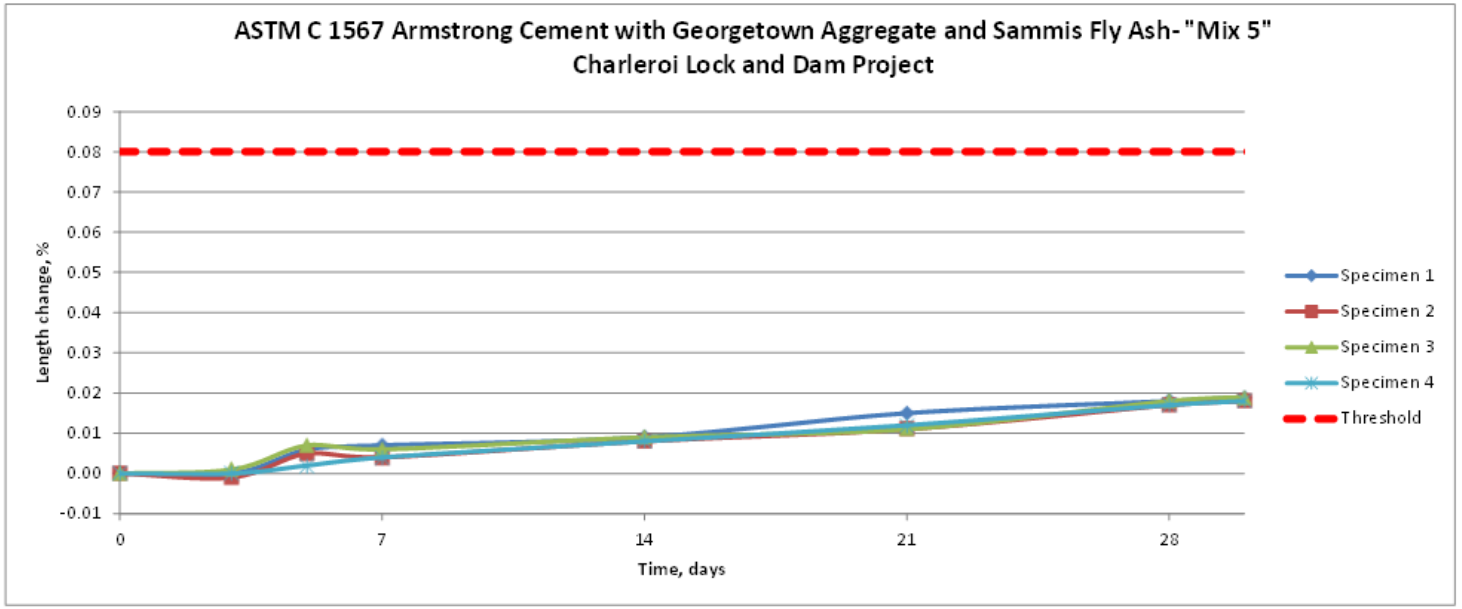
Mix:	Mix 5 with Hanson Aggregate and Brandon Shores Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
			Specimen 1			Specimen 2			Specimen 3			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	3/20/2018		-	-	-	-	-	-	-	-	-	-	-
Initial	3/22/2018		-0.0066			-0.0038			-0.0043				
zero read	3/23/2018	0	0.0003		0.0000	0.0025		0.0000	0.0010		0.0000	0.0000	0.0000
	3/26/2018	3	0.0005	0.0002	0.0020	0.0028	0.0003	0.0030	0.0013	0.0003	0.0030	0.0027	0.0006
	3/28/2018	5	0.0010	0.0007	0.0070	0.0030	0.0005	0.0050	0.0015	0.0005	0.0050	0.0057	0.0012
	3/30/2018	7	0.0014	0.0011	0.0110	0.0033	0.0008	0.0080	0.0026	0.0016	0.0160	0.0117	0.0040
	4/6/2018	14	0.0038	0.0035	0.0350	0.0055	0.0030	0.0300	0.0044	0.0034	0.0340	0.0330	0.0026
	4/20/2018	28	0.0048	0.0045	0.0450	0.0065	0.0040	0.0400	0.0053	0.0043	0.0430	0.0427	0.0025
	4/23/2018	30	0.0050	0.0047	0.0470	0.0066	0.0041	0.0410	0.0054	0.0044	0.0440	0.0440	0.0030

Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.



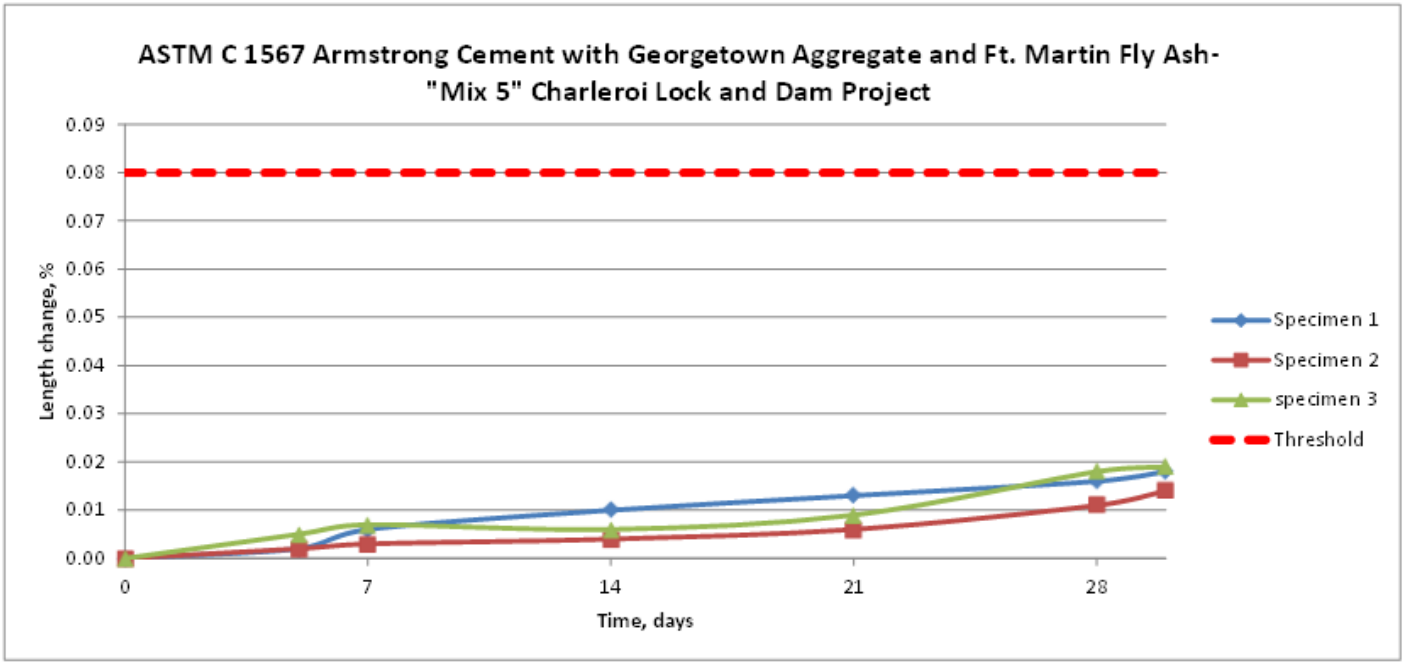
Mix:	Mix 5 with Georgetown Aggregate and Sammis Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	4/21/2015		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	4/23/2015		0.0002			-0.0012			0.0009			0.0049				
zero read	4/24/2015	0	0.0070		0.0000	0.0054		0.0000	0.0078		0.0000	0.0118		0.0000	0.0000	0.0000
	4/27/2015	3	0.0070	0.0000	0.0000	0.0053	-0.0001	-0.0010	0.0079	0.0001	0.0010	0.0118	0.0000	0.0000	0.0000	0.0008
	4/29/2015	5	0.0076	0.0006	0.0060	0.0059	0.0005	0.0050	0.0085	0.0007	0.0070	0.0120	0.0002	0.0020	0.0050	0.0022
	5/1/2015	7	0.0077	0.0007	0.0070	0.0058	0.0004	0.0040	0.0084	0.0006	0.0060	0.0122	0.0004	0.0040	0.0053	0.0015
	5/8/2015	14	0.0079	0.0009	0.0090	0.0062	0.0008	0.0080	0.0087	0.0009	0.0090	0.0126	0.0008	0.0080	0.0085	0.0006
	5/15/2015	21	0.0085	0.0015	0.0150	0.0065	0.0011	0.0110	0.0089	0.0011	0.0110	0.0130	0.0012	0.0120	0.0123	0.0019
	5/22/2015	28	0.0088	0.0018	0.0180	0.0071	0.0017	0.0170	0.0096	0.0018	0.0180	0.0135	0.0017	0.0170	0.0175	0.0006
	5/24/2015	30	0.0089	0.0019	0.0190	0.0072	0.0018	0.0180	0.0097	0.0019	0.0190	0.0136	0.0018	0.0180	0.0185	0.0006

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.

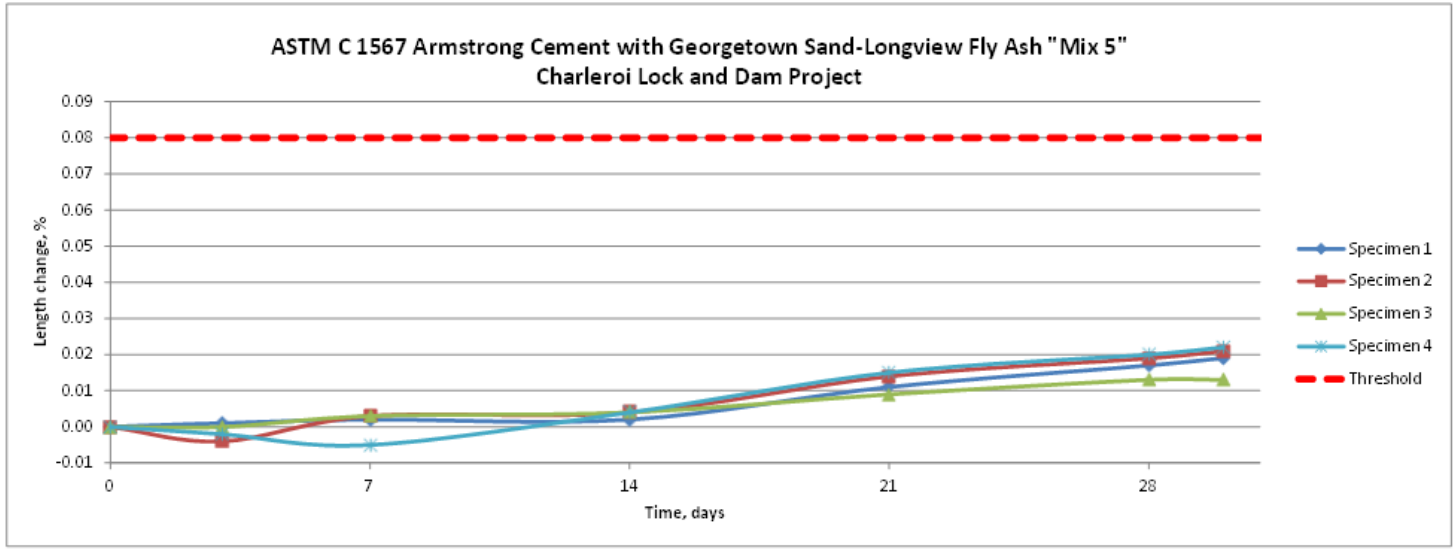


Mix:	Mix 5 with Georgetown Aggregate and Ft. Martin Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
	Date		Specimen 1			Specimen 2			Specimen 3			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	4/28/2015		-	-	-	-	-	-	-	-	-	-	-
Initial	4/30/2015		-0.0026			0.0025			-0.0022				
zero read	5/1/2015	0	0.0042		0.0000	0.0043		0.0000	0.0042		0.0000	0.0000	0.0000
	5/6/2015	5	0.0044	0.0002	0.0020	0.0045	0.0002	0.0020	0.0047	0.0005	0.0050	0.0030	0.0017
	5/8/2015	7	0.0048	0.0006	0.0060	0.0046	0.0003	0.0030	0.0049	0.0007	0.0070	0.0053	0.0021
	5/15/2015	14	0.0052	0.0010	0.0100	0.0047	0.0004	0.0040	0.0048	0.0006	0.0060	0.0067	0.0031
	5/22/2015	21	0.0055	0.0013	0.0130	0.0049	0.0006	0.0060	0.0051	0.0009	0.0090	0.0093	0.0035
	5/29/2015	28	0.0058	0.0016	0.0160	0.0054	0.0011	0.0110	0.0060	0.0018	0.0180	0.0150	0.0036
	5/31/2015	30	0.0060	0.0018	0.0180	0.0057	0.0014	0.0140	0.0061	0.0019	0.0190	0.0170	0.0026

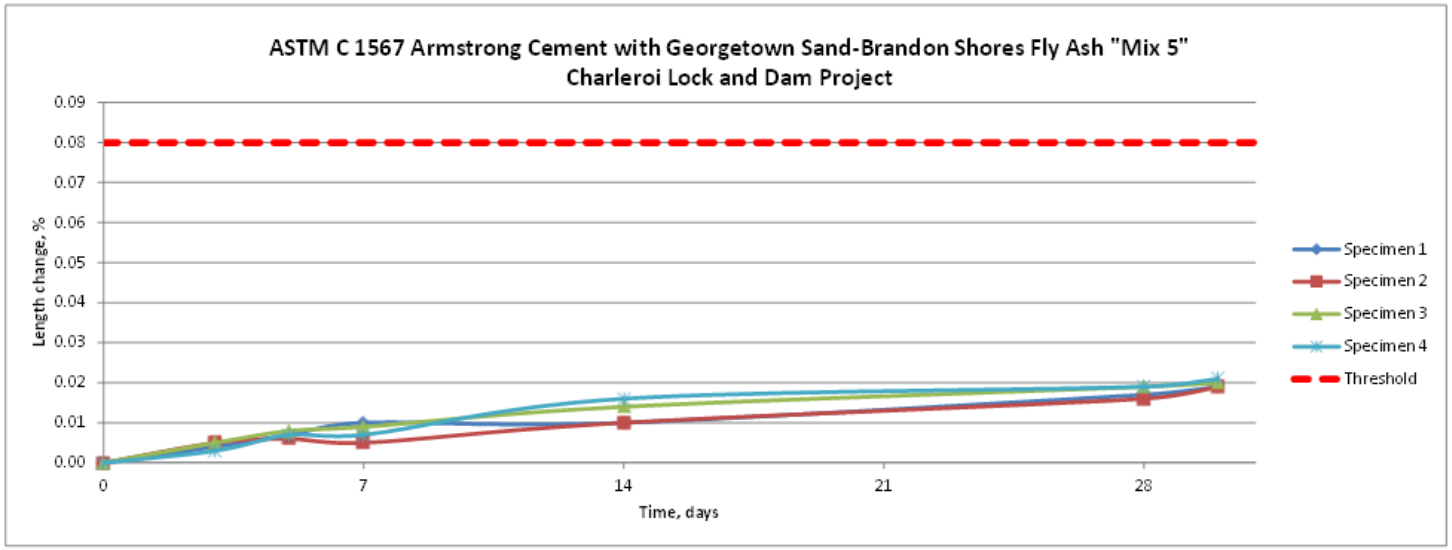
* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.



Mix:	Mix 5 with Georgetown Sand and Longview Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/MYr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/28/2017		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	11/30/2017		-0.0122			-0.0057			-0.0100			-0.0088				
zero read	12/1/2017	0	-0.0051		0.0000	0.0012		0.0000	-0.0028		0.0000	-0.0019		0.0000	0.0000	0.0000
	12/4/2017	3	-0.0050	0.0001	0.0010	0.0008	-0.0004	-0.0040	-0.0028	0.0000	0.0000	-0.0021	-0.0002	-0.0020	-0.0013	0.0022
	12/8/2017	7	-0.0049	0.0002	0.0020	0.0015	0.0003	0.0030	-0.0025	0.0003	0.0030	-0.0024	-0.0005	-0.0050	0.0008	0.0039
	12/15/2017	14	-0.0049	0.0002	0.0020	0.0016	0.0004	0.0040	-0.0024	0.0004	0.0040	-0.0015	0.0004	0.0040	0.0035	0.0010
	12/22/2017	21	-0.0040	0.0011	0.0110	0.0026	0.0014	0.0140	-0.0019	0.0009	0.0090	-0.0004	0.0015	0.0150	0.0123	0.0028
	12/29/2017	28	-0.0034	0.0017	0.0170	0.0031	0.0019	0.0190	-0.0015	0.0013	0.0130	0.0001	0.0020	0.0200	0.0173	0.0031
	12/31/2017	30	-0.0032	0.0019	0.0190	0.0033	0.0021	0.0210	-0.0015	0.0013	0.0130	0.0003	0.0022	0.0220	0.0188	0.0040
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.																

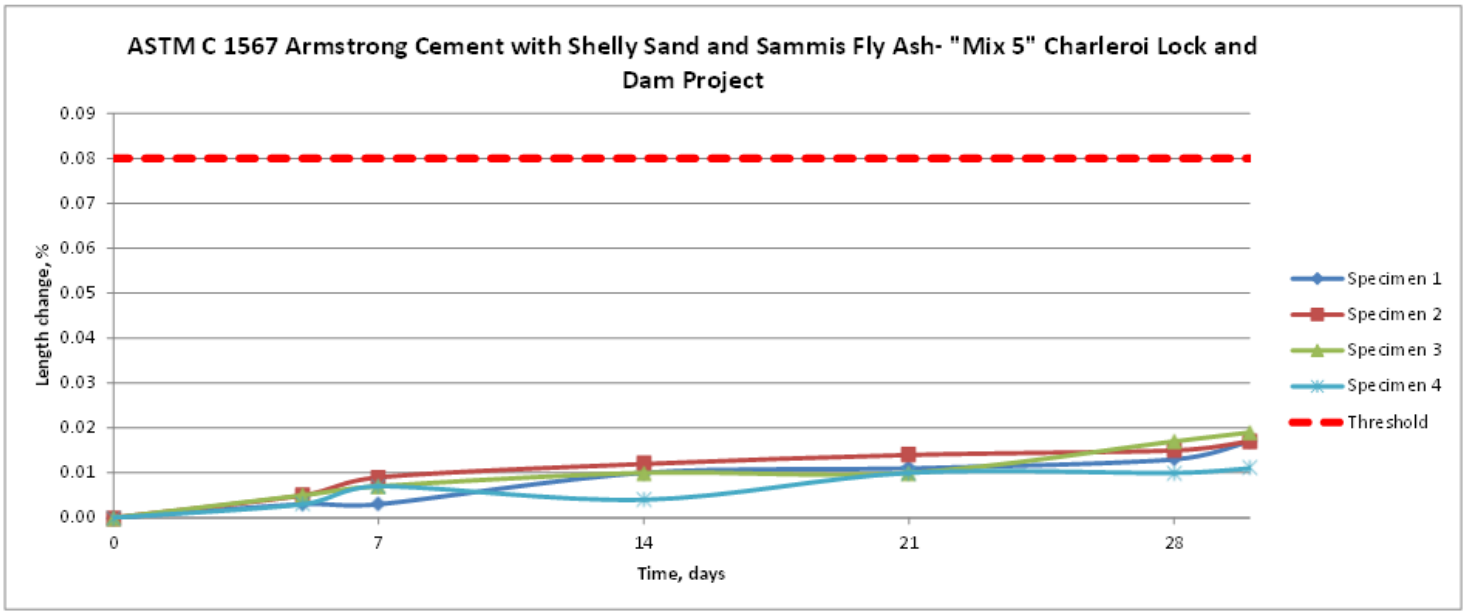


Mix:	Mix 5 with Georgetown Sand and Brandon Shores Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/MYr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	3/20/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	3/22/2018		-0.0151			0.0019			-0.0103			-0.0134				
zero read	3/23/2018	0	-0.0085		0.0000	0.0089		0.0000	-0.0039		0.0000	-0.0066		0.0000	0.0000	0.0000
	3/26/2018	3	-0.0081	0.0004	0.0040	0.0094	0.0005	0.0050	-0.0034	0.0005	0.0050	-0.0063	0.0003	0.0030	0.0043	0.0010
	3/28/2018	5	-0.0078	0.0007	0.0070	0.0095	0.0006	0.0060	-0.0031	0.0008	0.0080	-0.0059	0.0007	0.0070	0.0070	0.0008
	3/30/2018	7	-0.0075	0.0010	0.0100	0.0094	0.0005	0.0050	-0.0030	0.0009	0.0090	-0.0059	0.0007	0.0070	0.0078	0.0022
	4/6/2018	14	-0.0075	0.0010	0.0100	0.0099	0.0010	0.0100	-0.0025	0.0014	0.0140	-0.0050	0.0016	0.0160	0.0125	0.0030
	4/20/2018	28	-0.0068	0.0017	0.0170	0.0105	0.0016	0.0160	-0.0020	0.0019	0.0190	-0.0047	0.0019	0.0190	0.0178	0.0015
	4/23/2018	30	-0.0066	0.0019	0.0190	0.0108	0.0019	0.0190	-0.0019	0.0020	0.0200	-0.0045	0.0021	0.0210	0.0198	0.0010
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.																



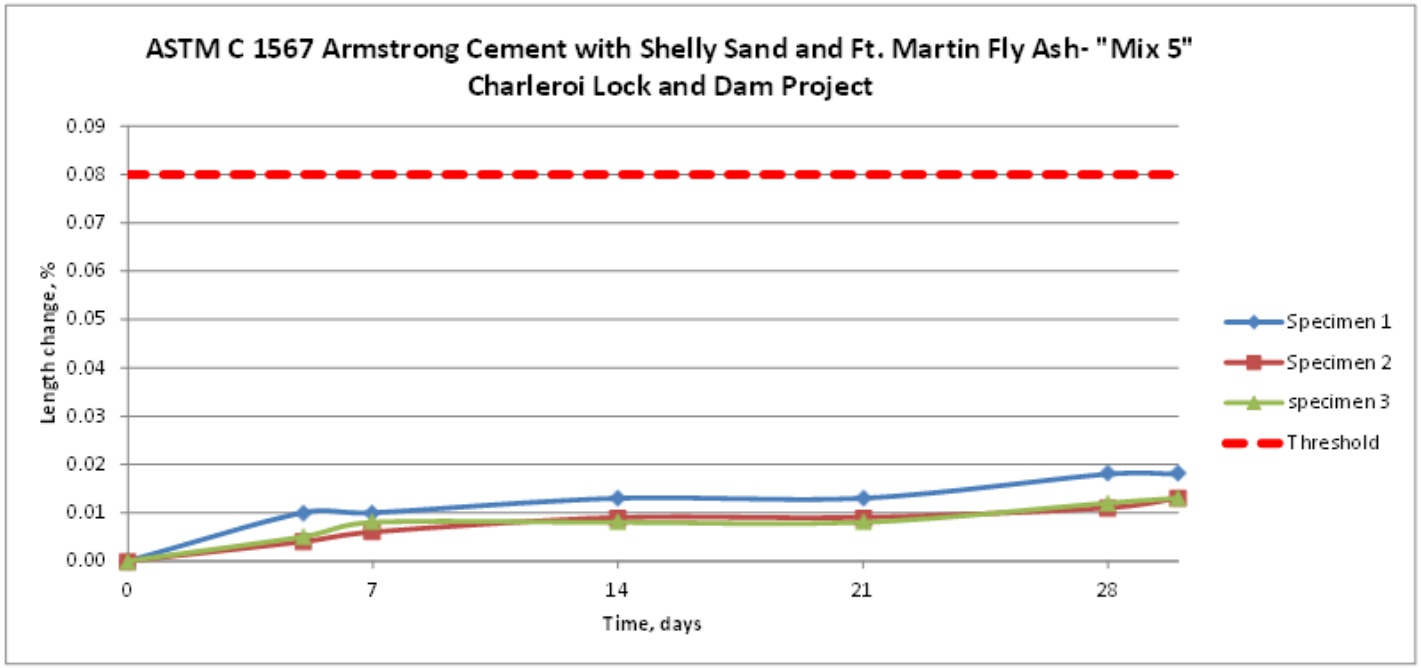
Mix:	Mix 5 with Shelly Sand and Sammis Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/17/2015		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	11/19/2015		-0.0050			-0.0016			-0.0078			-0.0063				
zero read	11/20/2015	0	0.0019		0.0000	0.0051		0.0000	-0.0013		0.0000	-0.0007		0.0000	0.0000	0.0000
	11/25/2015	5	0.0022	0.0003	0.0030	0.0056	0.0005	0.0050	-0.0008	0.0005	0.0050	-0.0004	0.0003	0.0030	0.0040	0.0012
	11/27/2015	7	0.0022	0.0003	0.0030	0.0060	0.0009	0.0090	-0.0006	0.0007	0.0070	0.0000	0.0007	0.0070	0.0065	0.0025
	12/4/2015	14	0.0029	0.0010	0.0100	0.0063	0.0012	0.0120	-0.0003	0.0010	0.0100	-0.0003	0.0004	0.0040	0.0090	0.0035
	12/11/2015	21	0.0030	0.0011	0.0110	0.0065	0.0014	0.0140	-0.0003	0.0010	0.0100	0.0003	0.0010	0.0100	0.0113	0.0019
	12/18/2015	28	0.0032	0.0013	0.0130	0.0066	0.0015	0.0150	0.0004	0.0017	0.0170	0.0003	0.0010	0.0100	0.0138	0.0030
	12/20/2015	30	0.0036	0.0017	0.0170	0.0068	0.0017	0.0170	0.0006	0.0019	0.0190	0.0004	0.0011	0.0110	0.0160	0.0035

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.

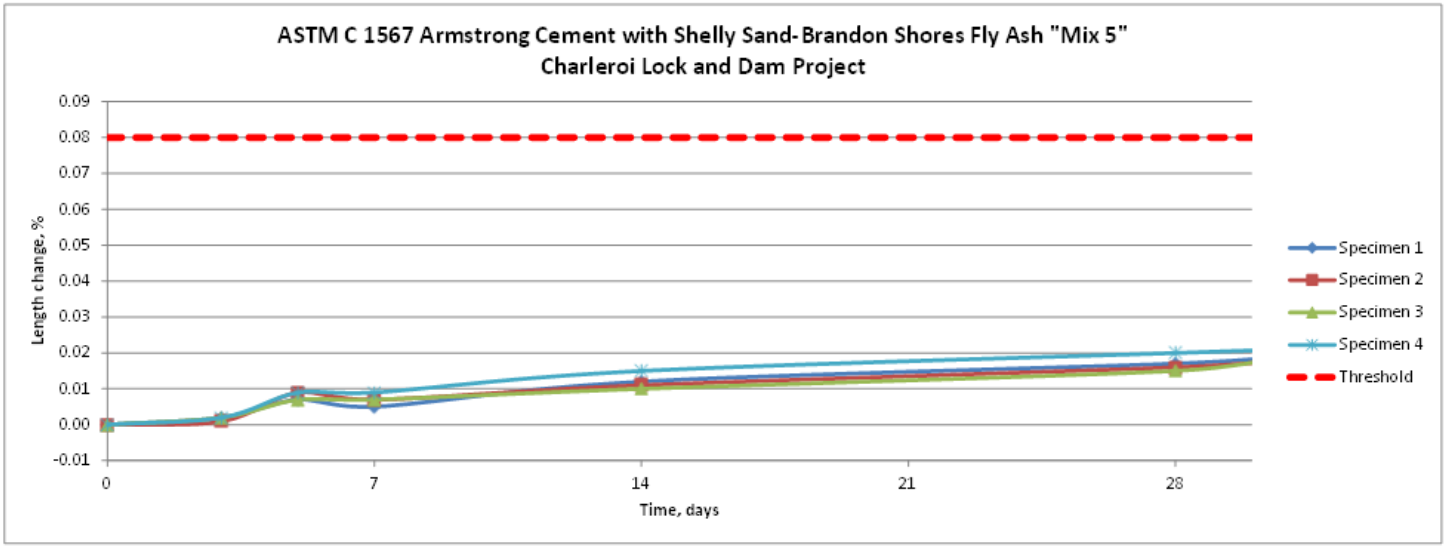


Mix:	Mix 5 with Shelley Aggregate and Ft. Martin Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
	Date		Specimen 1			Specimen 2			Specimen 3			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/17/2015		-	-	-	-	-	-	-	-	-	-	-
Initial	11/19/2015		-0.0011			-0.0138			-0.0116				
zero read	11/20/2015	0	0.0042		0.0000	-0.0071		0.0000	-0.0048		0.0000	0.0000	0.0000
	11/25/2015	5	0.0052	0.0010	0.0100	-0.0067	0.0004	0.0040	-0.0043	0.0005	0.0050	0.0063	0.0032
	11/27/2015	7	0.0052	0.0010	0.0100	-0.0065	0.0006	0.0060	-0.0040	0.0008	0.0080	0.0080	0.0020
	12/4/2015	14	0.0055	0.0013	0.0130	-0.0062	0.0009	0.0090	-0.0040	0.0008	0.0080	0.0100	0.0026
	12/11/2015	21	0.0055	0.0013	0.0130	-0.0062	0.0009	0.0090	-0.0040	0.0008	0.0080	0.0100	0.0026
	12/18/2015	28	0.0060	0.0018	0.0180	-0.0060	0.0011	0.0110	-0.0036	0.0012	0.0120	0.0137	0.0038
	12/20/2015	30	0.0060	0.0018	0.0180	-0.0058	0.0013	0.0130	-0.0035	0.0013	0.0130	0.0147	0.0029

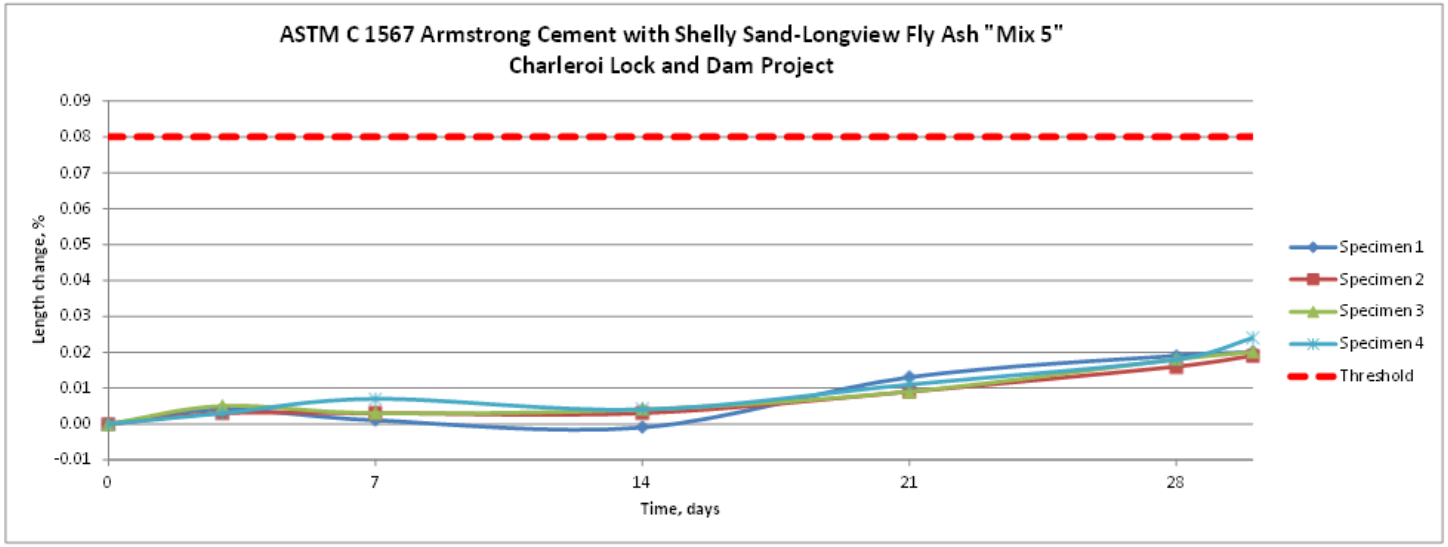
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.



Mix:	Mix 5 with Shelley Sand and Brandon Shores Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	3/20/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	3/22/2018		-0.0026			-0.0013			-0.0117			-0.0045				
zero read	3/23/2018	0	0.0040		0.0000	0.0054		0.0000	-0.0050		0.0000	0.0020		0.0000	0.0000	0.0000
	3/26/2018	3	0.0042	0.0002	0.0020	0.0055	0.0001	0.0010	-0.0048	0.0002	0.0020	0.0022	0.0002	0.0020	0.0018	0.0005
	3/28/2018	5	0.0047	0.0007	0.0070	0.0063	0.0009	0.0090	-0.0043	0.0007	0.0070	0.0029	0.0009	0.0090	0.0080	0.0012
	3/30/2018	7	0.0045	0.0005	0.0050	0.0061	0.0007	0.0070	-0.0043	0.0007	0.0070	0.0029	0.0009	0.0090	0.0070	0.0016
	4/6/2018	14	0.0052	0.0012	0.0120	0.0065	0.0011	0.0110	-0.0040	0.0010	0.0100	0.0035	0.0015	0.0150	0.0120	0.0022
	4/20/2018	28	0.0057	0.0017	0.0170	0.0070	0.0016	0.0160	-0.0035	0.0015	0.0150	0.0040	0.0020	0.0200	0.0170	0.0022
	4/23/2018	31	0.0059	0.0019	0.0190	0.0072	0.0018	0.0180	-0.0031	0.0019	0.0190	0.0041	0.0021	0.0210	0.0193	0.0013
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.																

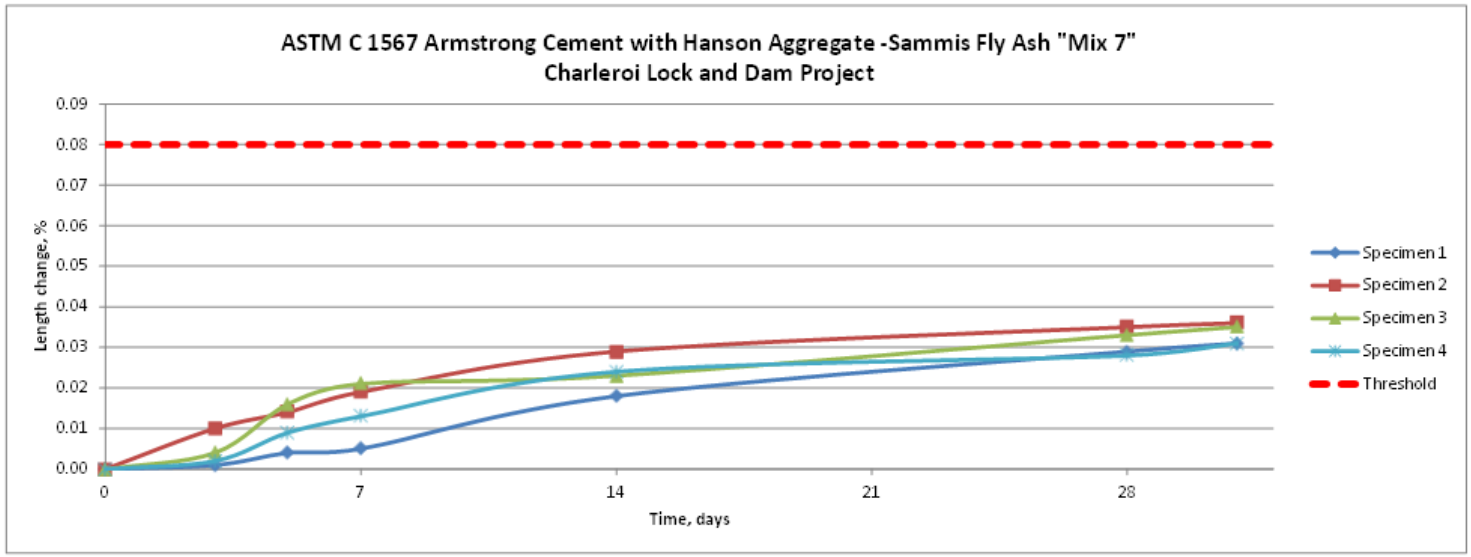


Mix:	Mix 5 with Shelley Sand and Longview Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/MYr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/28/2017		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	11/30/2017		-0.0081			-0.0355			-0.0106			-0.0123				
zero read	12/1/2017	0	-0.0012		0.0000	-0.0286		0.0000	-0.0038		0.0000	-0.0058		0.0000	0.0000	0.0000
	12/4/2017	3	-0.0008	0.0004	0.0040	-0.0283	0.0003	0.0030	-0.0033	0.0005	0.0050	-0.0055	0.0003	0.0030	0.0038	0.0010
	12/8/2017	7	-0.0011	0.0001	0.0010	-0.0283	0.0003	0.0030	-0.0035	0.0003	0.0030	-0.0051	0.0007	0.0070	0.0035	0.0025
	12/15/2017	14	-0.0013	-0.0001	-0.0010	-0.0283	0.0003	0.0030	-0.0034	0.0004	0.0040	-0.0054	0.0004	0.0040	0.0025	0.0024
	12/22/2017	21	0.0001	0.0013	0.0130	-0.0277	0.0009	0.0090	-0.0029	0.0009	0.0090	-0.0047	0.0011	0.0110	0.0105	0.0019
	12/29/2017	28	0.0007	0.0019	0.0190	-0.0270	0.0016	0.0160	-0.0020	0.0018	0.0180	-0.0040	0.0018	0.0180	0.0178	0.0013
	12/31/2017	30	0.0008	0.0020	0.0200	-0.0267	0.0019	0.0190	-0.0018	0.0020	0.0200	-0.0034	0.0024	0.0240	0.0208	0.0022
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.																

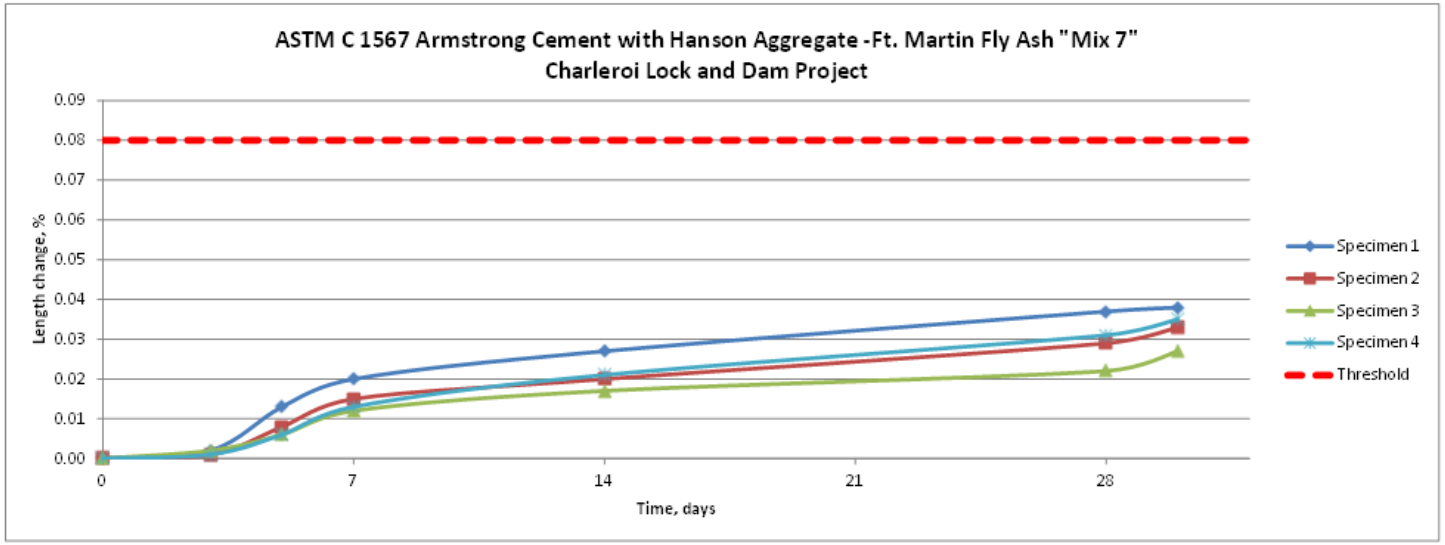


Mix:	Mix 7 with Hanson Aggregate and Sammis Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	4/24/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	4/26/2018		-0.0008			-0.0078			-0.0073			-0.0104				
zero read	4/27/2018	0	0.0065		0.0000	-0.0009		0.0000	-0.0006		0.0000	-0.0038		0.0000	0.0000	0.0000
	4/30/2018	3	0.0066	0.0001	0.0010	0.0001	0.0010	0.0100	-0.0002	0.0004	0.0040	-0.0036	0.0002	0.0020	0.0043	0.0040
	5/2/2018	5	0.0069	0.0004	0.0040	0.0005	0.0014	0.0140	0.0010	0.0016	0.0160	-0.0029	0.0009	0.0090	0.0108	0.0054
	5/4/2018	7	0.0070	0.0005	0.0050	0.0010	0.0019	0.0190	0.0015	0.0021	0.0210	-0.0025	0.0013	0.0130	0.0145	0.0072
	5/11/2018	14	0.0083	0.0018	0.0180	0.0020	0.0029	0.0290	0.0017	0.0023	0.0230	-0.0014	0.0024	0.0240	0.0235	0.0045
	5/25/2018	28	0.0094	0.0029	0.0290	0.0026	0.0035	0.0350	0.0027	0.0033	0.0330	-0.0010	0.0028	0.0280	0.0313	0.0033
	5/28/2018	31	0.0096	0.0031	0.0310	0.0027	0.0036	0.0360	0.0029	0.0035	0.0350	-0.0007	0.0031	0.0310	0.0333	0.0026

Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.

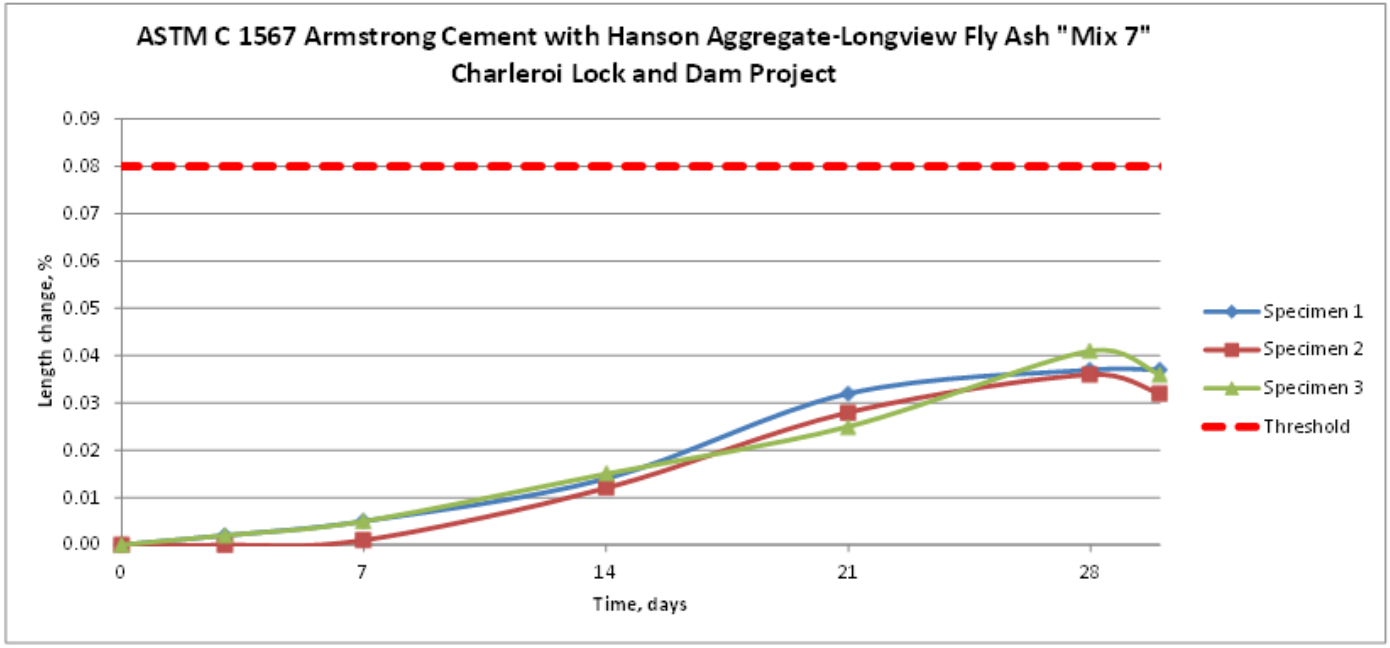


Mix:	Mix 7 with Hanson Aggregate and Ft. Martin Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/MYr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	5/1/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	5/3/2018		-0.0080			-0.0015			0.0089			0.0008				
zero read	5/4/2018	0	-0.0015		0.0000	0.0055		0.0000	0.0163		0.0000	0.0077		0.0000	0.0000	0.0000
	5/7/2018	3	-0.0013	0.0002	0.0020	0.0056	0.0001	0.0010	0.0165	0.0002	0.0020	0.0078	0.0001	0.0010	0.0015	0.0006
	5/9/2018	5	-0.0002	0.0013	0.0130	0.0063	0.0008	0.0080	0.0169	0.0006	0.0060	0.0083	0.0006	0.0060	0.0083	0.0033
	5/11/2018	7	0.0005	0.0020	0.0200	0.0070	0.0015	0.0150	0.0175	0.0012	0.0120	0.0090	0.0013	0.0130	0.0150	0.0036
	5/18/2018	14	0.0012	0.0027	0.0270	0.0075	0.0020	0.0200	0.0180	0.0017	0.0170	0.0098	0.0021	0.0210	0.0213	0.0042
	6/1/2018	28	0.0022	0.0037	0.0370	0.0084	0.0029	0.0290	0.0185	0.0022	0.0220	0.0108	0.0031	0.0310	0.0298	0.0062
	6/4/2018	30	0.0023	0.0038	0.0380	0.0088	0.0033	0.0330	0.0190	0.0027	0.0270	0.0112	0.0035	0.0350	0.0333	0.0046
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.																

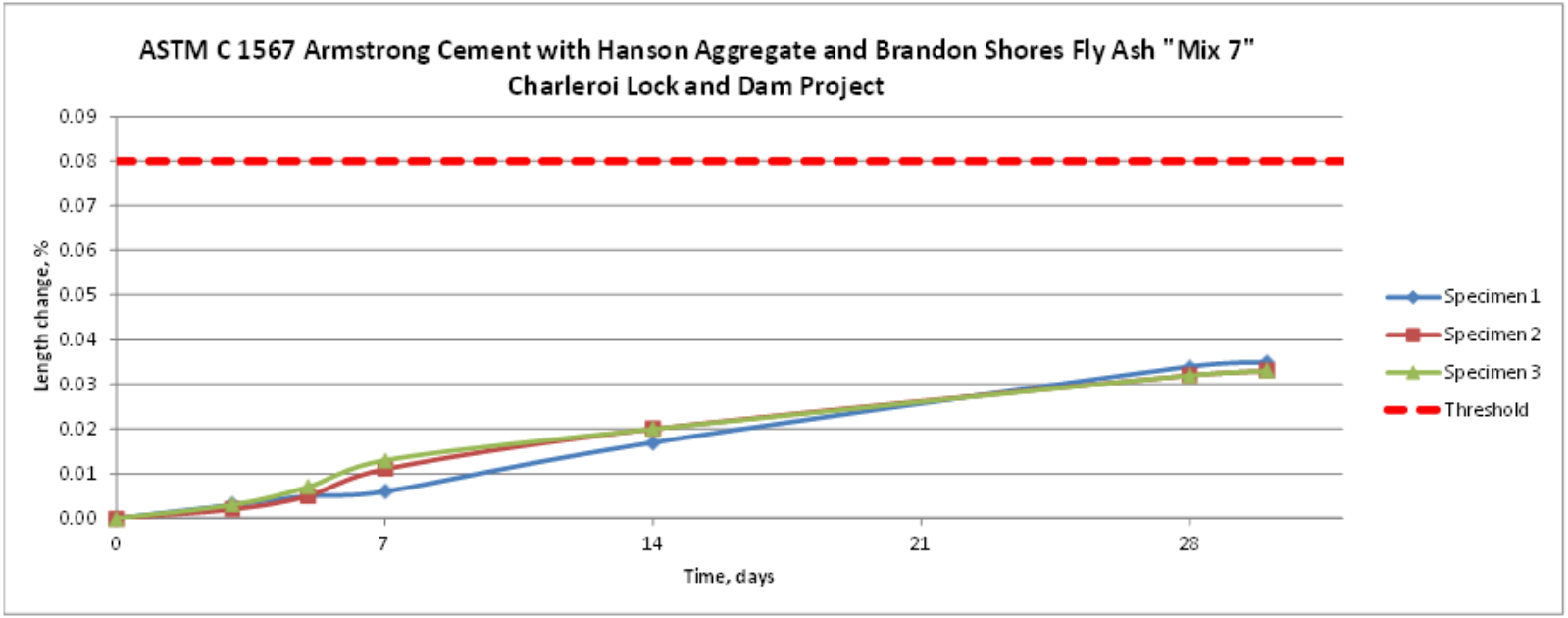


Mix:	Mix 7 with Hanson Aggregate and Longview Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
			Specimen 1			Specimen 2			Specimen 3			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/28/2017		-	-	-	-	-	-	-	-	-	-	-
Initial	11/30/2017		-0.0075			-0.0412			-0.0102				
zero read	12/1/2017	0	-0.0013		0.0000	-0.0352		0.0000	-0.0040		0.0000	0.0000	0.0000
	12/4/2017	3	-0.0011	0.0002	0.0020	-0.0352	0.0000	0.0000	-0.0038	0.0002	0.0020	0.0013	0.0012
	12/8/2017	7	-0.0008	0.0005	0.0050	-0.0351	0.0001	0.0010	-0.0035	0.0005	0.0050	0.0037	0.0023
	12/15/2017	14	0.0001	0.0014	0.0140	-0.0340	0.0012	0.0120	-0.0025	0.0015	0.0150	0.0137	0.0015
	12/22/2017	21	0.0019	0.0032	0.0320	-0.0324	0.0028	0.0280	-0.0015	0.0025	0.0250	0.0283	0.0035
	12/29/2017	28	0.0024	0.0037	0.0370	-0.0316	0.0036	0.0360	0.0001	0.0041	0.0410	0.0380	0.0026
	12/31/2017	30	0.0024	0.0037	0.0370	-0.0320	0.0032	0.0320	-0.0004	0.0036	0.0360	0.0350	0.0026

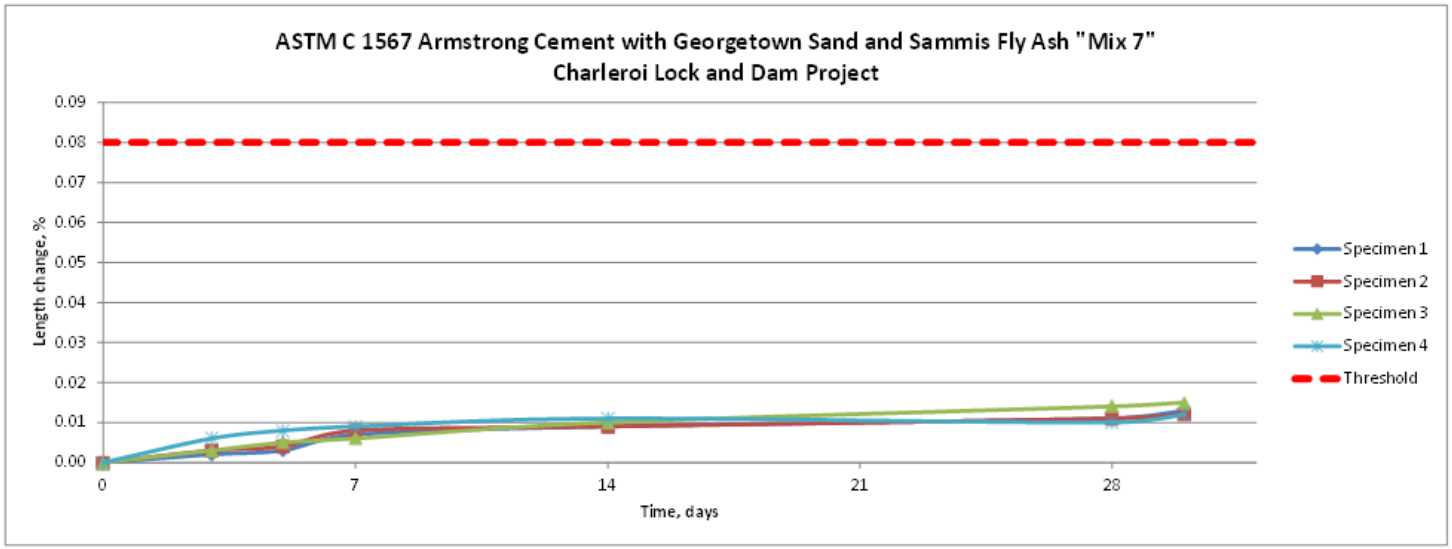
* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.



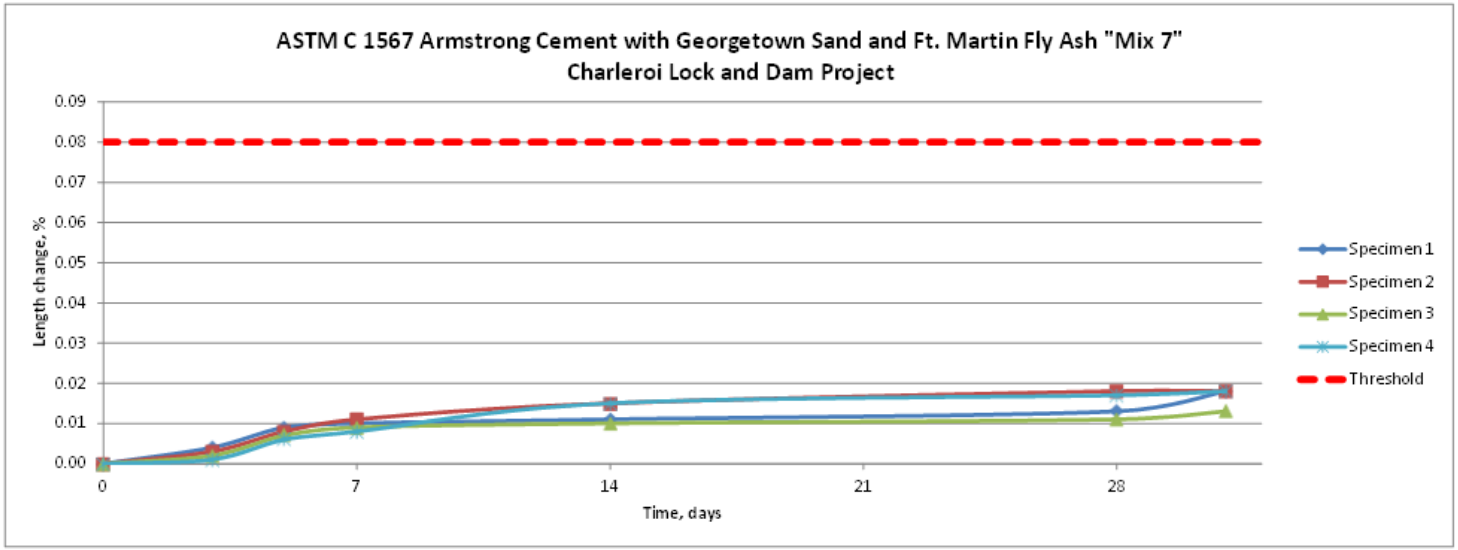
Mix:	Mix 7 with Hanson and Brandon Shores Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
			Specimen 1			Specimen 2			Specimen 3			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/MYr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	3/20/2018		-	-	-	-	-	-	-	-	-	-	-
Initial	3/22/2018		-0.0038			0.0273			0.0112				
zero read	3/23/2018	0	0.0036		0.0000	0.0330		0.0000	0.0169		0.0000	0.0000	0.0000
	3/26/2018	3	0.0039	0.0003	0.0030	0.0332	0.0002	0.0020	0.0172	0.0003	0.0030	0.0027	0.0006
	3/28/2018	5	0.0041	0.0005	0.0050	0.0335	0.0005	0.0050	0.0176	0.0007	0.0070	0.0057	0.0012
	3/30/2018	7	0.0042	0.0006	0.0060	0.0341	0.0011	0.0110	0.0182	0.0013	0.0130	0.0100	0.0036
	4/6/2018	14	0.0053	0.0017	0.0170	0.0350	0.0020	0.0200	0.0189	0.0020	0.0200	0.0190	0.0017
	4/20/2018	28	0.0070	0.0034	0.0340	0.0362	0.0032	0.0320	0.0201	0.0032	0.0320	0.0327	0.0012
	4/23/2018	30	0.0071	0.0035	0.0350	0.0363	0.0033	0.0330	0.0202	0.0033	0.0330	0.0337	0.0012
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.													



Mix:	Mix 7 with Georgetown and Sammis Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	4/24/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	4/26/2018		-0.0062			-0.0039			-0.0095			-0.0095				
zero read	4/27/2018	0	0.0007		0.0000	0.0028		0.0000	-0.0026		0.0000	-0.0032		0.0000	0.0000	0.0000
	4/30/2018	3	0.0009	0.0002	0.0020	0.0031	0.0003	0.0030	-0.0023	0.0003	0.0030	-0.0026	0.0006	0.0060	0.0035	0.0017
	5/2/2018	5	0.0010	0.0003	0.0030	0.0032	0.0004	0.0040	-0.0021	0.0005	0.0050	-0.0024	0.0008	0.0080	0.0050	0.0022
	5/4/2018	7	0.0014	0.0007	0.0070	0.0036	0.0008	0.0080	-0.0020	0.0006	0.0060	-0.0023	0.0009	0.0090	0.0075	0.0013
	5/11/2018	14	0.0016	0.0009	0.0090	0.0037	0.0009	0.0090	-0.0016	0.0010	0.0100	-0.0021	0.0011	0.0110	0.0098	0.0010
	5/25/2018	28	0.0018	0.0011	0.0110	0.0039	0.0011	0.0110	-0.0012	0.0014	0.0140	-0.0022	0.0010	0.0100	0.0115	0.0017
	5/28/2018	30	0.0020	0.0013	0.0130	0.0040	0.0012	0.0120	-0.0011	0.0015	0.0150	-0.0020	0.0012	0.0120	0.0130	0.0014
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.																

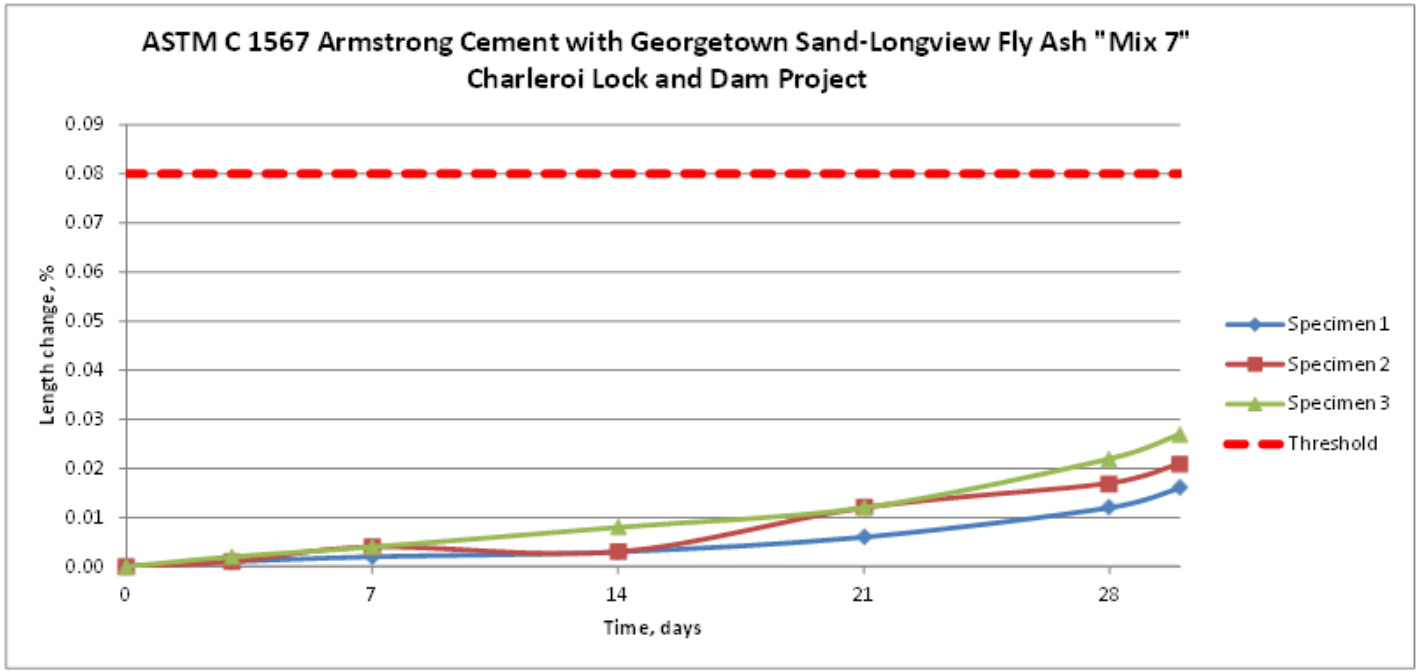


Mix:	Mix 7 with Georgetown and Ft. Martin Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	5/1/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	5/3/2018		-0.0128			-0.0039			0.0017			-0.0099				
zero read	5/4/2018	0	-0.0059		0.0000	0.0029		0.0000	0.0090		0.0000	-0.0030		0.0000	0.0000	0.0000
	5/7/2018	3	-0.0055	0.0004	0.0040	0.0032	0.0003	0.0030	0.0092	0.0002	0.0020	-0.0029	0.0001	0.0010	0.0025	0.0013
	5/9/2018	5	-0.0050	0.0009	0.0090	0.0037	0.0008	0.0080	0.0097	0.0007	0.0070	-0.0024	0.0006	0.0060	0.0075	0.0013
	5/11/2018	7	-0.0049	0.0010	0.0100	0.0040	0.0011	0.0110	0.0099	0.0009	0.0090	-0.0022	0.0008	0.0080	0.0095	0.0013
	5/18/2018	14	-0.0048	0.0011	0.0110	0.0044	0.0015	0.0150	0.0100	0.0010	0.0100	-0.0015	0.0015	0.0150	0.0128	0.0026
	6/1/2018	28	-0.0046	0.0013	0.0130	0.0047	0.0018	0.0180	0.0101	0.0011	0.0110	-0.0013	0.0017	0.0170	0.0148	0.0033
	6/4/2018	31	-0.0041	0.0018	0.0180	0.0047	0.0018	0.0180	0.0103	0.0013	0.0130	-0.0012	0.0018	0.0180	0.0168	0.0025
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.																



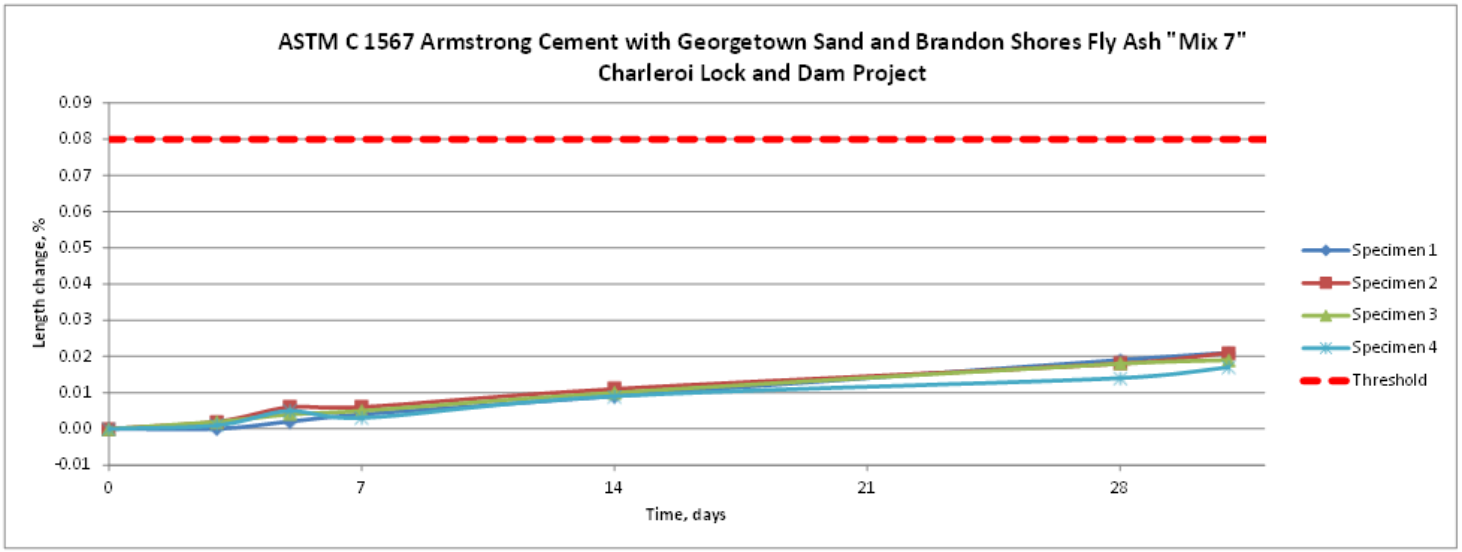
Mix:	Mix 7 with Georgetown Sand and Longview Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
			Specimen 1			Specimen 2			Specimen 3			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/28/2017		-	-	-	-	-	-	-	-	-	-	-
Initial	11/30/2017		-0.0079			-0.0124			-0.0120				
zero read	12/1/2017	0	-0.0010		0.0000	-0.0056		0.0000	-0.0052		0.0000	0.0000	0.0000
	12/4/2017	3	-0.0009	0.0001	0.0010	-0.0055	0.0001	0.0010	-0.0050	0.0002	0.0020	0.0013	0.0006
	12/8/2017	7	-0.0008	0.0002	0.0020	-0.0052	0.0004	0.0040	-0.0048	0.0004	0.0040	0.0033	0.0012
	12/15/2017	14	-0.0007	0.0003	0.0030	-0.0053	0.0003	0.0030	-0.0044	0.0008	0.0080	0.0047	0.0029
	12/22/2017	21	-0.0004	0.0006	0.0060	-0.0044	0.0012	0.0120	-0.0040	0.0012	0.0120	0.0100	0.0035
	12/29/2017	28	0.0002	0.0012	0.0120	-0.0039	0.0017	0.0170	-0.0030	0.0022	0.0220	0.0170	0.0050
	12/31/2017	30	0.0006	0.0016	0.0160	-0.0035	0.0021	0.0210	-0.0025	0.0027	0.0270	0.0213	0.0055

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.



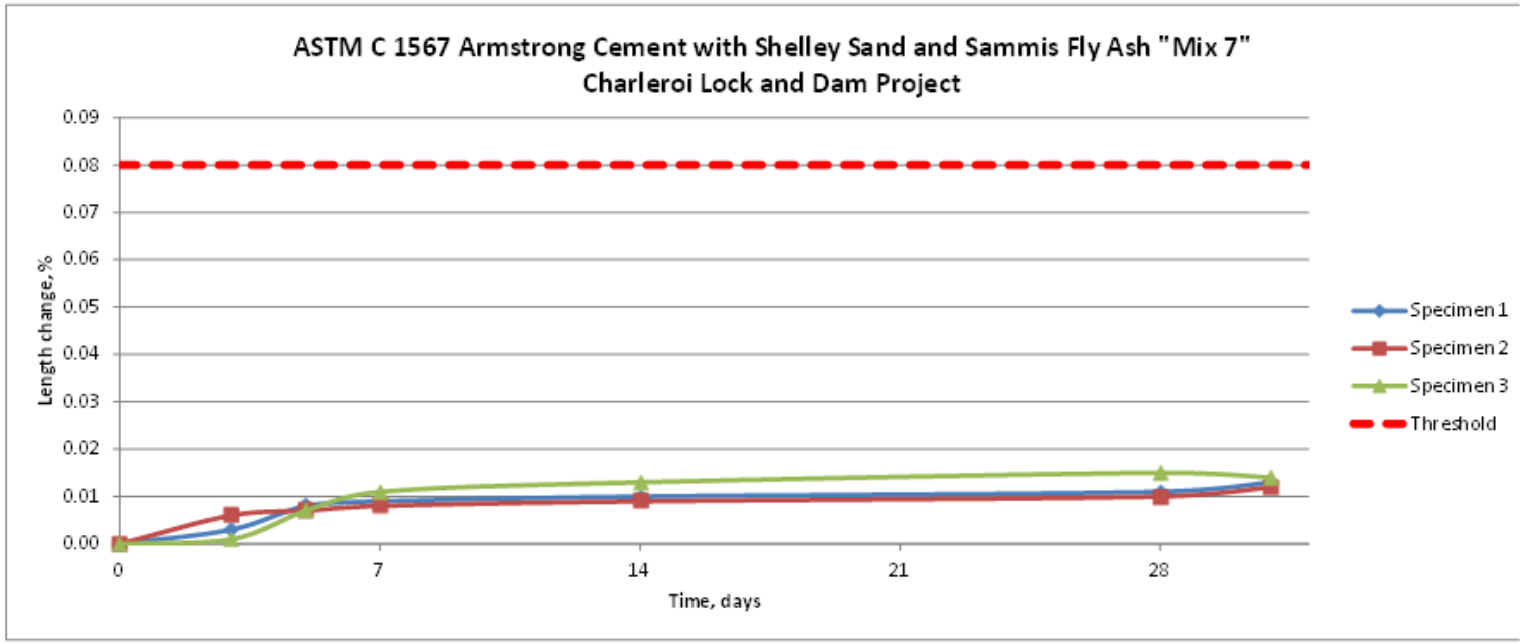
Mix:	Mix 7 with Georgetown and Brandon Shores Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	3/20/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	3/22/2018		0.0007			-0.0063			-0.0039			0.0032				
zero read	3/23/2018	0	0.0071		0.0000	0.0000		0.0000	0.0021		0.0000	0.0091		0.0000	0.0000	0.0000
	3/26/2018	3	0.0071	0.0000	0.0000	0.0002	0.0002	0.0020	0.0023	0.0002	0.0020	0.0092	0.0001	0.0010	0.0013	0.0010
	3/28/2018	5	0.0073	0.0002	0.0020	0.0006	0.0006	0.0060	0.0025	0.0004	0.0040	0.0096	0.0005	0.0050	0.0043	0.0017
	3/30/2018	7	0.0075	0.0004	0.0040	0.0006	0.0006	0.0060	0.0026	0.0005	0.0050	0.0094	0.0003	0.0030	0.0045	0.0013
	4/6/2018	14	0.0080	0.0009	0.0090	0.0011	0.0011	0.0110	0.0031	0.0010	0.0100	0.0100	0.0009	0.0090	0.0098	0.0010
	4/20/2018	28	0.0090	0.0019	0.0190	0.0018	0.0018	0.0180	0.0039	0.0018	0.0180	0.0105	0.0014	0.0140	0.0173	0.0022
	4/23/2018	31	0.0092	0.0021	0.0210	0.0021	0.0021	0.0210	0.0040	0.0019	0.0190	0.0108	0.0017	0.0170	0.0195	0.0019

Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.



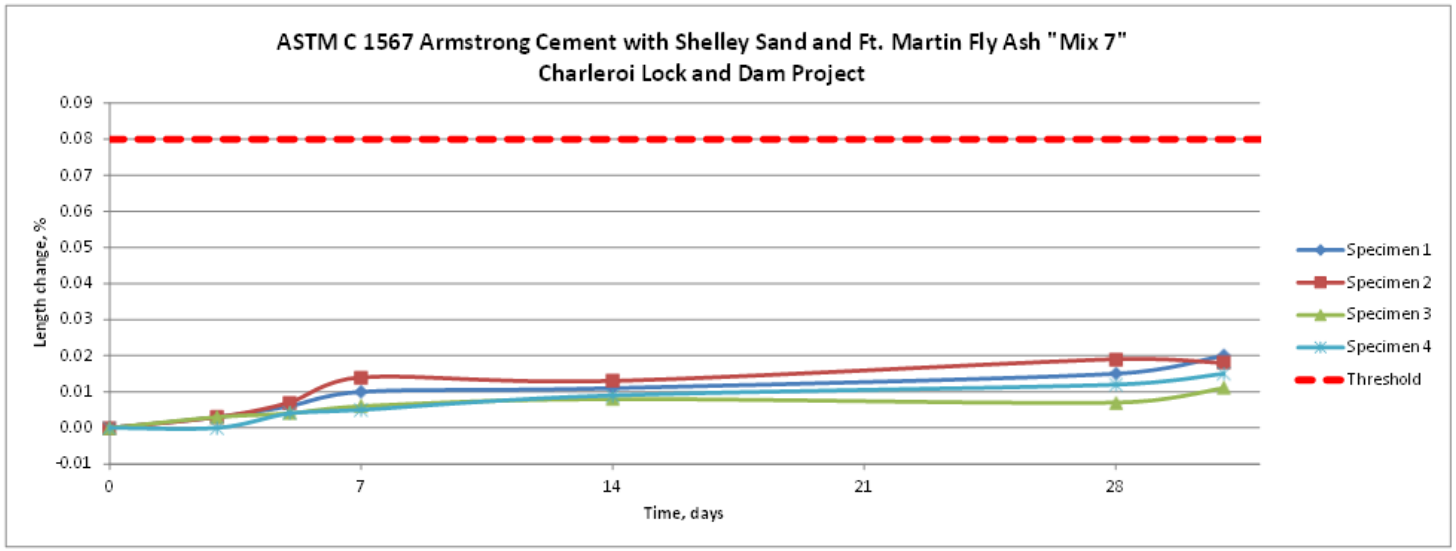
Mix:	Mix 7 with Shelley Sand and Sammis Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
			Specimen 1			Specimen 2			Specimen 3			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/MYr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	4/24/2018		-	-	-	-	-	-	-	-	-	-	-
Initial	4/26/2018		-0.0053			-0.0034			-0.0104				
zero read	4/27/2018	0	0.0015		0.0000	0.0033		0.0000	-0.0040		0.0000	0.0000	0.0000
	4/30/2018	3	0.0018	0.0003	0.0030	0.0039	0.0006	0.0060	-0.0039	0.0001	0.0010	0.0033	0.0025
	5/2/2018	5	0.0023	0.0008	0.0080	0.0040	0.0007	0.0070	-0.0033	0.0007	0.0070	0.0073	0.0006
	5/4/2018	7	0.0024	0.0009	0.0090	0.0041	0.0008	0.0080	-0.0029	0.0011	0.0110	0.0093	0.0015
	5/11/2018	14	0.0025	0.0010	0.0100	0.0042	0.0009	0.0090	-0.0027	0.0013	0.0130	0.0107	0.0021
	5/25/2018	28	0.0026	0.0011	0.0110	0.0043	0.0010	0.0100	-0.0025	0.0015	0.0150	0.0120	0.0026
	5/28/2018	31	0.0028	0.0013	0.0130	0.0045	0.0012	0.0120	-0.0026	0.0014	0.0140	0.0130	0.0010

Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.

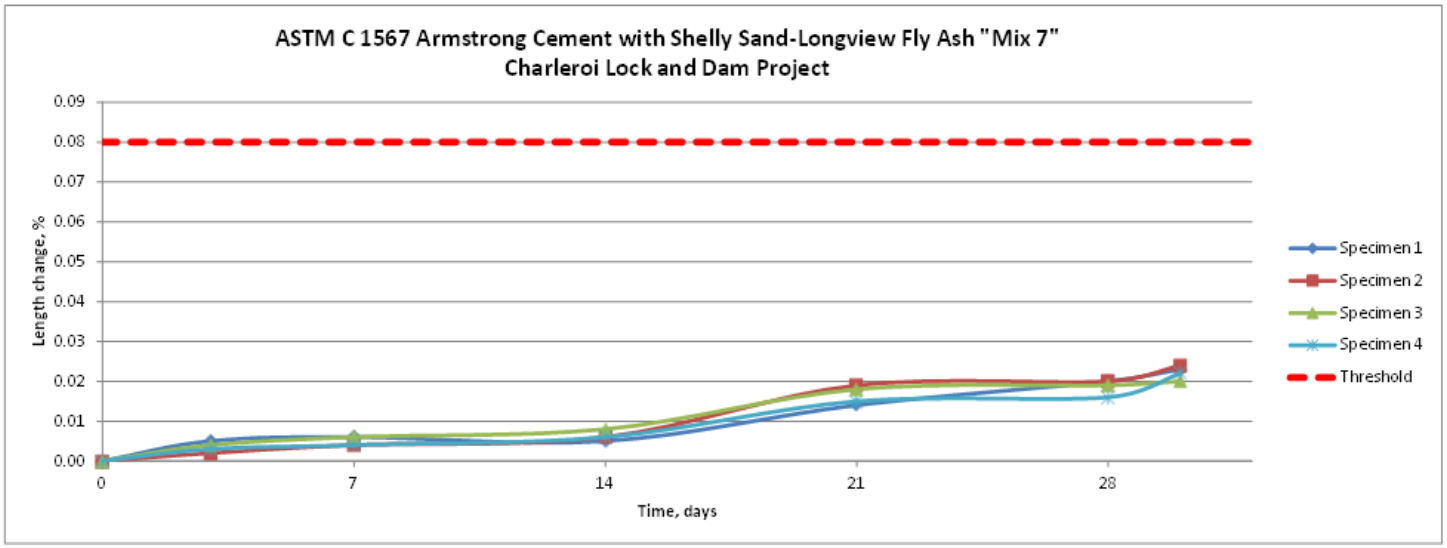


Mix:	Mix 7 with Shelley Sand and Ft. Martin Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	5/1/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	5/3/2018		-0.0106			-0.0106			-0.0096			-0.0052				
zero read	5/4/2018	0	-0.0033		0.0000	-0.0037		0.0000	-0.0026		0.0000	0.0021		0.0000	0.0000	0.0000
	5/7/2018	3	-0.0030	0.0003	0.0030	-0.0034	0.0003	0.0030	-0.0023	0.0003	0.0030	0.0021	0.0000	0.0000	0.0023	0.0015
	5/9/2018	5	-0.0027	0.0006	0.0060	-0.0030	0.0007	0.0070	-0.0022	0.0004	0.0040	0.0025	0.0004	0.0040	0.0053	0.0015
	5/11/2018	7	-0.0023	0.0010	0.0100	-0.0023	0.0014	0.0140	-0.0020	0.0006	0.0060	0.0026	0.0005	0.0050	0.0088	0.0041
	5/18/2018	14	-0.0022	0.0011	0.0110	-0.0024	0.0013	0.0130	-0.0018	0.0008	0.0080	0.0030	0.0009	0.0090	0.0103	0.0022
	6/1/2018	28	-0.0018	0.0015	0.0150	-0.0018	0.0019	0.0190	-0.0019	0.0007	0.0070	0.0033	0.0012	0.0120	0.0133	0.0051
	6/4/2018	31	-0.0013	0.0020	0.0200	-0.0019	0.0018	0.0180	-0.0015	0.0011	0.0110	0.0036	0.0015	0.0150	0.0160	0.0039

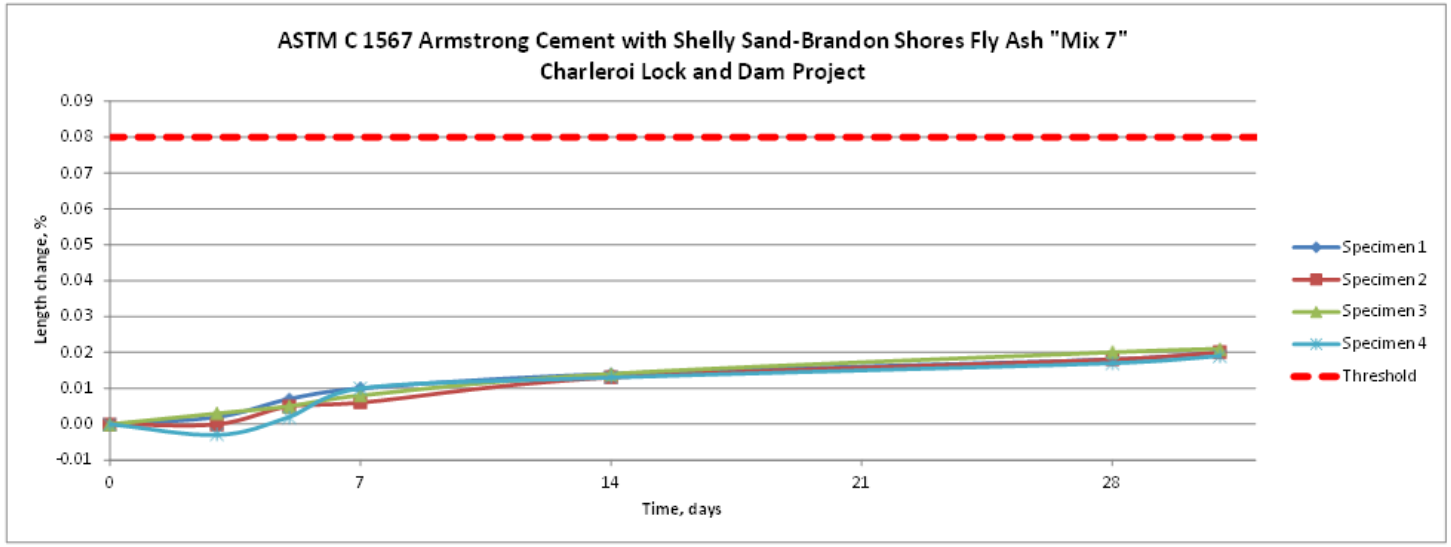
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.



Mix:	Mix 7 with Shelley Sand and Longview Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	11/28/2017		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	11/30/2017		-0.0105			-0.0033			-0.0193			-0.0202				
zero read	12/1/2017	0	-0.0040		0.0000	0.0033		0.0000	-0.0132		0.0000	-0.0137		0.0000	0.0000	0.0000
	12/4/2017	3	-0.0035	0.0005	0.0050	0.0035	0.0002	0.0020	-0.0128	0.0004	0.0040	-0.0134	0.0003	0.0030	0.0035	0.0013
	12/8/2017	7	-0.0034	0.0006	0.0060	0.0037	0.0004	0.0040	-0.0126	0.0006	0.0060	-0.0133	0.0004	0.0040	0.0050	0.0012
	12/15/2017	14	-0.0035	0.0005	0.0050	0.0039	0.0006	0.0060	-0.0124	0.0008	0.0080	-0.0131	0.0006	0.0060	0.0063	0.0013
	12/22/2017	21	-0.0026	0.0014	0.0140	0.0052	0.0019	0.0190	-0.0114	0.0018	0.0180	-0.0122	0.0015	0.0150	0.0165	0.0024
	12/29/2017	28	-0.0020	0.0020	0.0200	0.0053	0.0020	0.0200	-0.0113	0.0019	0.0190	-0.0121	0.0016	0.0160	0.0188	0.0019
	12/31/2017	30	-0.0017	0.0023	0.0230	0.0057	0.0024	0.0240	-0.0112	0.0020	0.0200	-0.0115	0.0022	0.0220	0.0223	0.0017
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.																

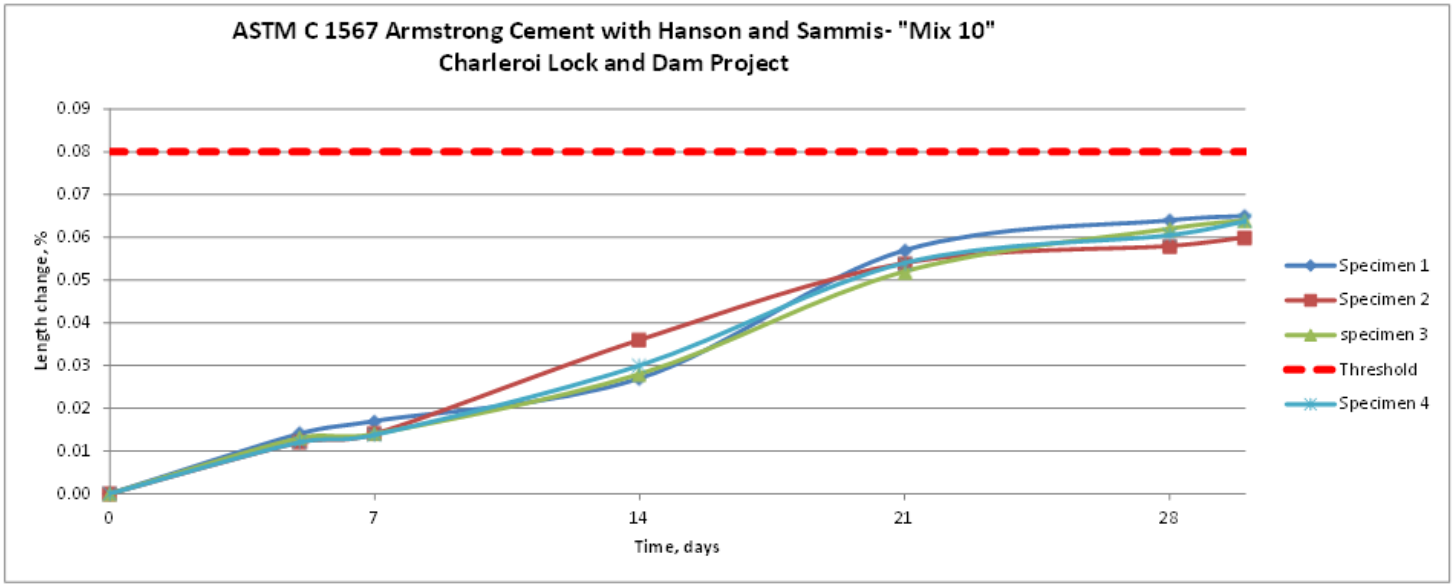


Mix:	Mix 7 with Shelley Sand and Brandon Shores Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	3/20/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	3/22/2018		-0.0075			-0.0013			-0.0095			-0.0094				
zero read	3/23/2018	0	-0.0017		0.0000	0.0047		0.0000	-0.0030		0.0000	-0.0028		0.0000	0.0000	0.0000
	3/26/2018	3	-0.0015	0.0002	0.0020	0.0047	0.0000	0.0000	-0.0027	0.0003	0.0030	-0.0031	-0.0003	-0.0030	0.0005	0.0026
	3/28/2018	5	-0.0010	0.0007	0.0070	0.0052	0.0005	0.0050	-0.0025	0.0005	0.0050	-0.0026	0.0002	0.0020	0.0048	0.0021
	3/30/2018	7	-0.0007	0.0010	0.0100	0.0053	0.0006	0.0060	-0.0017	0.0008	0.0080	-0.0018	0.0010	0.0100	0.0085	0.0019
	4/6/2018	14	-0.0003	0.0014	0.0140	0.0060	0.0013	0.0130	-0.0016	0.0014	0.0140	-0.0015	0.0013	0.0130	0.0135	0.0006
	4/20/2018	28	0.0001	0.0018	0.0180	0.0065	0.0018	0.0180	-0.0010	0.0020	0.0200	-0.0011	0.0017	0.0170	0.0183	0.0013
	4/23/2018	31	0.0003	0.0020	0.0200	0.0067	0.0020	0.0200	-0.0009	0.0021	0.0210	-0.0009	0.0019	0.0190	0.0200	0.0008
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.																



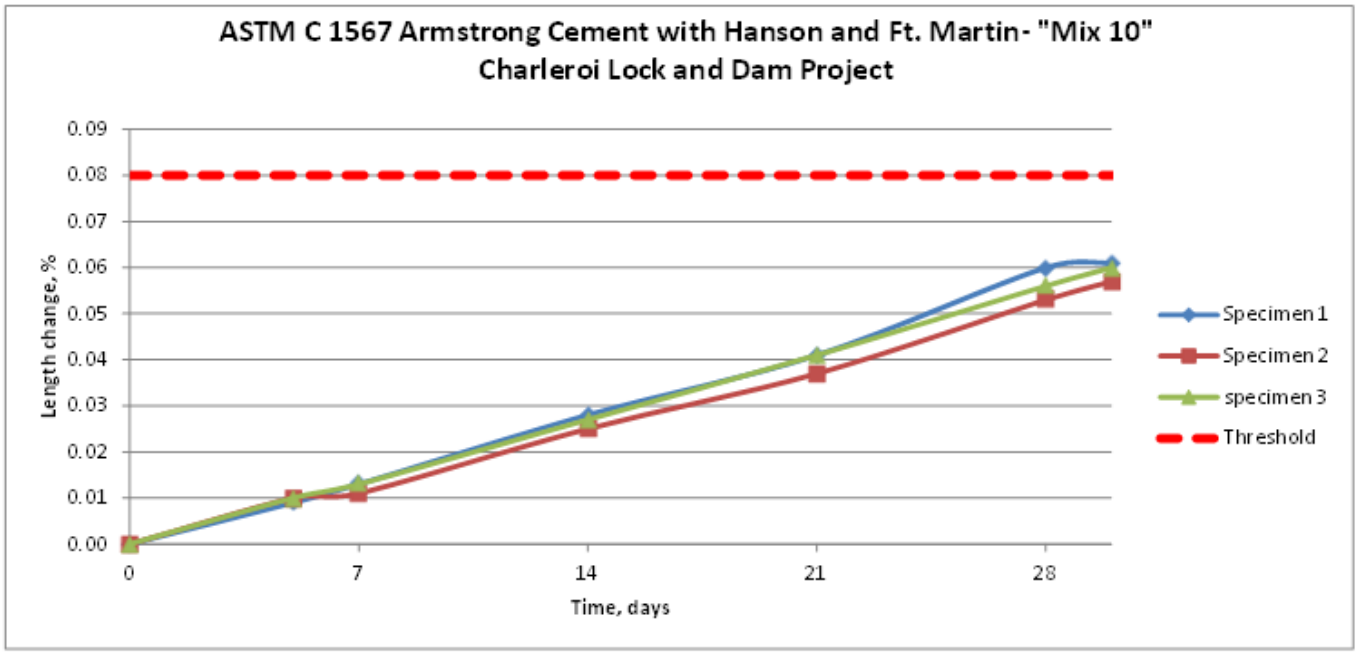
Mix:	Mix 10 with Hanson Aggregate and Sammis Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	10/11/2016		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	10/13/2016		-0.0070			-0.0058			-0.0029			0.0032				
zero read	10/14/2016	0	-0.0004		0.0000	0.0010		0.0000	0.0038		0.0000	0.0101			0.0000	0.0000
	10/19/2016	5	0.0010	0.0014	0.0140	0.0022	0.0012	0.0120	0.0051	0.0013	0.0130	0.0110	0.0009	0.0090	0.0120	0.0022
	10/21/2016	7	0.0013	0.0017	0.0170	0.0024	0.0014	0.0140	0.0052	0.0014	0.0140	0.0111	0.0010	0.0100	0.0138	0.0029
	10/28/2016	14	0.0023	0.0027	0.0270	0.0046	0.0036	0.0360	0.0066	0.0028	0.0280	0.0130	0.0029	0.0290	0.0300	0.0041
	11/4/2016	21	0.0053	0.0057	0.0570	0.0064	0.0054	0.0540	0.0090	0.0052	0.0520	0.0154	0.0053	0.0530	0.0540	0.0022
	11/11/2016	28	0.0060	0.0064	0.0640	0.0068	0.0058	0.0580	0.0100	0.0062	0.0620	0.0159	0.0058	0.0580	0.0605	0.0030
	11/13/2016	30	0.0061	0.0065	0.0650	0.0070	0.0060	0.0600	0.0102	0.0064	0.0640	0.0167	0.0066	0.0660	0.0638	0.0026

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.



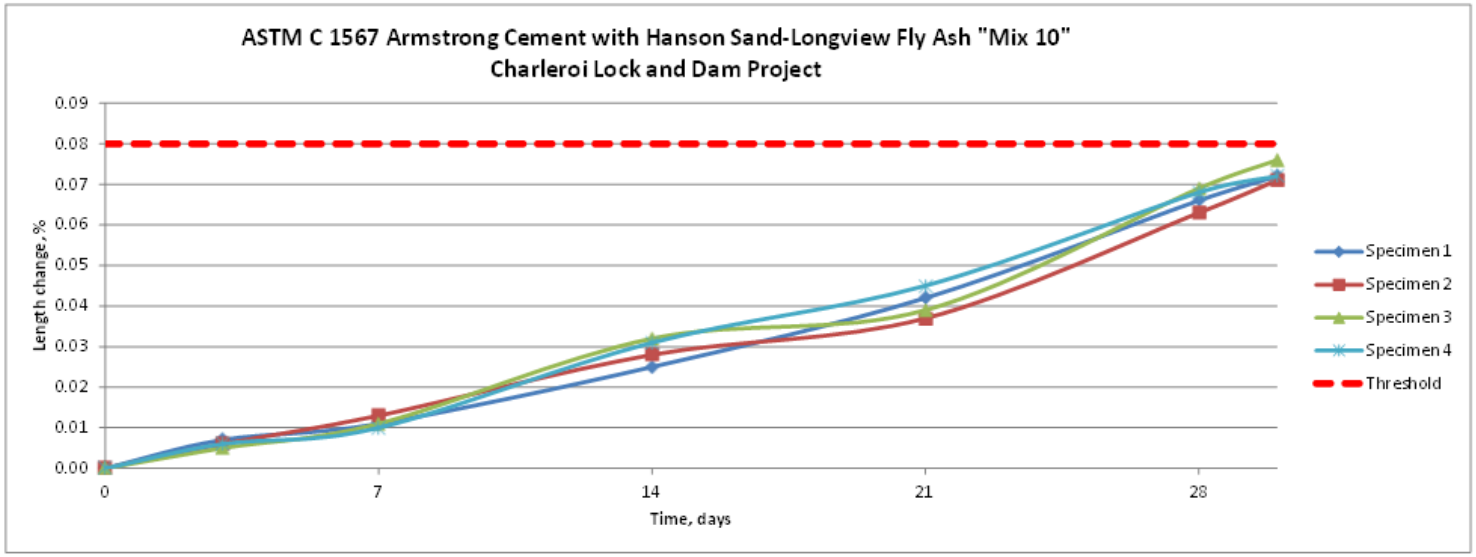
Mix:	Mix 10 with Hanson Aggregate and Ft. Martin Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
	Date		Specimen 1			Specimen 2			Specimen 3			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	10/11/2016		-	-	-	-	-	-	-	-	-	-	-
Initial	10/13/2016		-0.0048			-0.0011			-0.0050				
zero read	10/14/2016	0	0.0020		0.0000	0.0057		0.0000	0.0019		0.0000	0.0000	0.0000
	10/19/2016	5	0.0029	0.0009	0.0090	0.0067	0.0010	0.0100	0.0029	0.0010	0.0100	0.0097	0.0006
	10/21/2016	7	0.0033	0.0013	0.0130	0.0068	0.0011	0.0110	0.0032	0.0013	0.0130	0.0123	0.0012
	10/28/2016	14	0.0048	0.0028	0.0280	0.0082	0.0025	0.0250	0.0046	0.0027	0.0270	0.0267	0.0015
	11/4/2016	21	0.0061	0.0041	0.0410	0.0094	0.0037	0.0370	0.0060	0.0041	0.0410	0.0397	0.0023
	11/11/2016	28	0.0080	0.0060	0.0600	0.0110	0.0053	0.0530	0.0075	0.0056	0.0560	0.0563	0.0035
	11/13/2016	30	0.0081	0.0061	0.0610	0.0114	0.0057	0.0570	0.0079	0.0060	0.0600	0.0593	0.0021

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.



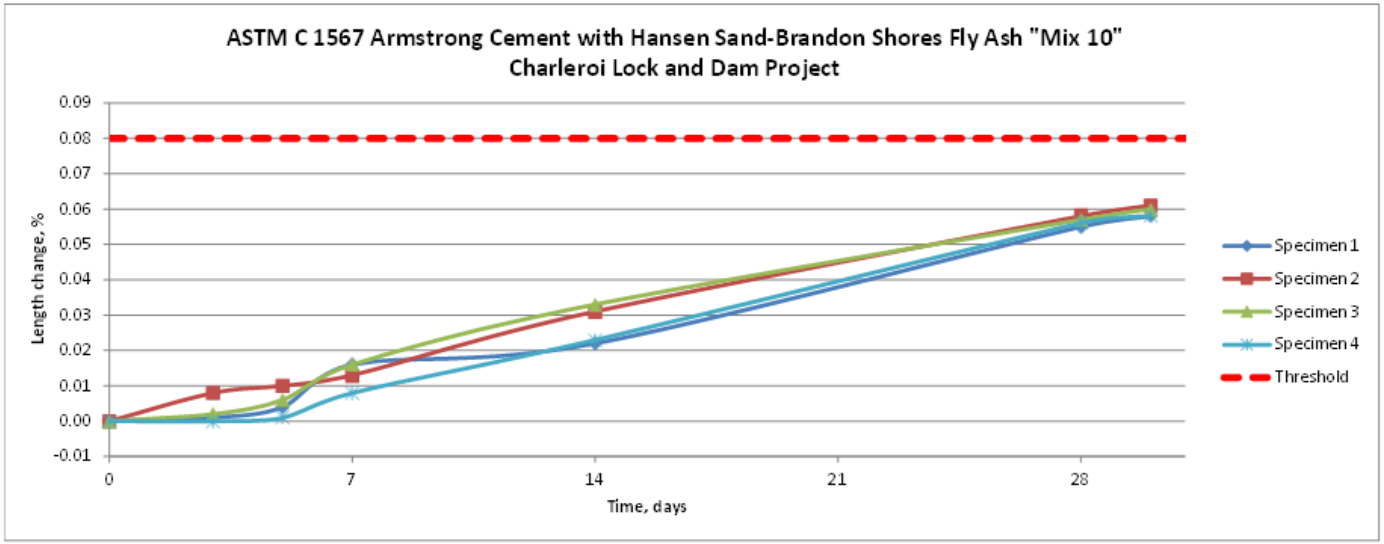
Mix:	Mix 10 with Hanson and Longview Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	12/5/2017		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	12/7/2017		-0.0056			-0.0089			-0.0087			-0.0061				
zero read	12/8/2017	0	0.0012		0.0000	-0.0017		0.0000	-0.0015		0.0000	0.0013		0.0000	0.0000	0.0000
	12/11/2017	3	0.0019	0.0007	0.0070	-0.0011	0.0006	0.0060	-0.0010	0.0005	0.0050	0.0019	0.0006	0.0060	0.0060	0.0008
	12/15/2017	7	0.0023	0.0011	0.0110	-0.0004	0.0013	0.0130	-0.0004	0.0011	0.0110	0.0023	0.0010	0.0100	0.0113	0.0013
	12/22/2017	14	0.0037	0.0025	0.0250	0.0011	0.0028	0.0280	0.0017	0.0032	0.0320	0.0044	0.0031	0.0310	0.0290	0.0032
	12/29/2017	21	0.0054	0.0042	0.0420	0.0020	0.0037	0.0370	0.0024	0.0039	0.0390	0.0058	0.0045	0.0450	0.0408	0.0035
	1/5/2018	28	0.0078	0.0066	0.0660	0.0046	0.0063	0.0630	0.0054	0.0069	0.0690	0.0081	0.0068	0.0680	0.0665	0.0026
	1/8/2018	30	0.0084	0.0072	0.0720	0.0054	0.0071	0.0710	0.0061	0.0076	0.0760	0.0085	0.0072	0.0720	0.0728	0.0022

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.



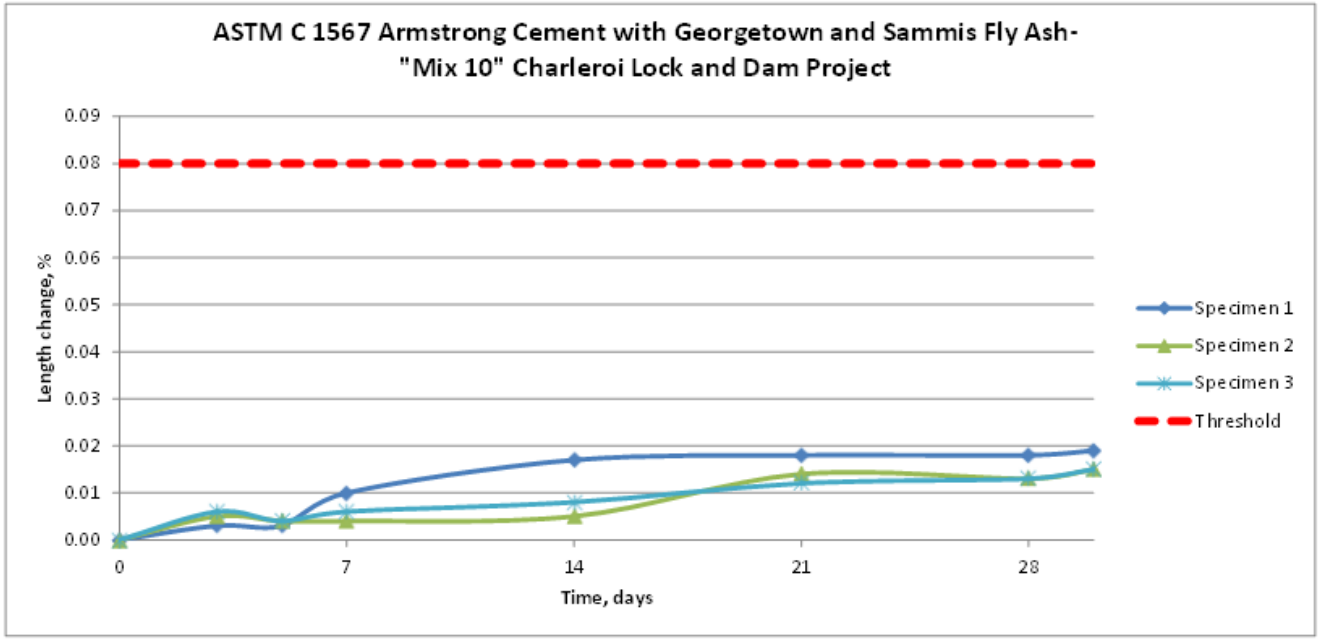
Mix:	Mix 10 with Hansen and Brandon Shores Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/MYr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	3/13/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	3/15/2018		-0.0044			-0.0091			-0.0018			-0.0021				
zero read	3/16/2018	0	0.0024		0.0000	-0.0043		0.0000	0.0050		0.0000	0.0047		0.0000	0.0000	0.0000
	3/19/2018	3	0.0025	0.0001	0.0010	-0.0035	0.0008	0.0080	0.0052	0.0002	0.0020	0.0047	0.0000	0.0000	0.0028	0.0036
	3/21/2018	5	0.0028	0.0004	0.0040	-0.0033	0.0010	0.0100	0.0056	0.0006	0.0060	0.0048	0.0001	0.0010	0.0053	0.0038
	3/23/2018	7	0.0040	0.0016	0.0160	-0.0030	0.0013	0.0130	0.0066	0.0016	0.0160	0.0055	0.0008	0.0080	0.0133	0.0038
	3/30/2018	14	0.0046	0.0022	0.0220	-0.0012	0.0031	0.0310	0.0083	0.0033	0.0330	0.0070	0.0023	0.0230	0.0273	0.0056
	4/13/2018	28	0.0079	0.0055	0.0550	0.0015	0.0058	0.0580	0.0107	0.0057	0.0570	0.0103	0.0056	0.0560	0.0565	0.0013
	4/15/2018	30	0.0082	0.0058	0.0580	0.0018	0.0061	0.0610	0.0110	0.0060	0.0600	0.0105	0.0058	0.0580	0.0593	0.0015

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.



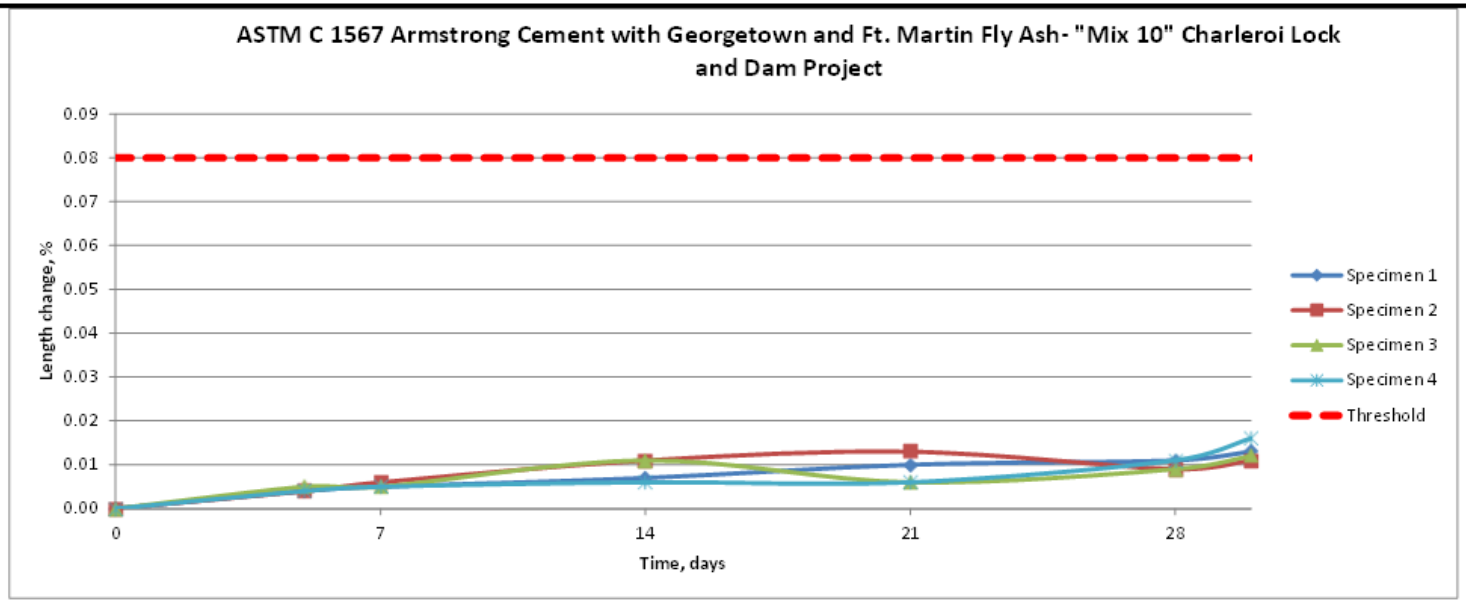
Mix:	Mix 10 with Georgetown and Sammis Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
	Date		Specimen 1			Specimen 2			Specimen 3			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	10/11/2016		-	-	-	-	-	-	-	-	-	-	-
Initial	10/13/2016		-0.0053			-0.0013			-0.0067				
zero read	10/14/2016	0	0.0012		0.0000	0.0052		0.0000	-0.0003		0.0000	0.0000	0.0000
	10/17/2016	3	0.0015	0.0003	0.0030	0.0057	0.0005	0.0050	0.0003	0.0006	0.0060	0.0047	0.0015
	10/19/2016	5	0.0015	0.0003	0.0030	0.0056	0.0004	0.0040	0.0001	0.0004	0.0040	0.0037	0.0006
	10/21/2016	7	0.0022	0.0010	0.0100	0.0056	0.0004	0.0040	0.0003	0.0006	0.0060	0.0067	0.0031
	10/28/2016	14	0.0029	0.0017	0.0170	0.0057	0.0005	0.0050	0.0005	0.0008	0.0080	0.0100	0.0062
	11/4/2016	21	0.0030	0.0018	0.0180	0.0066	0.0014	0.0140	0.0009	0.0012	0.0120	0.0147	0.0031
	11/11/2016	28	0.0030	0.0018	0.0180	0.0065	0.0013	0.0130	0.0010	0.0013	0.0130	0.0147	0.0029
	11/13/2016	30	0.0031	0.0019	0.0190	0.0067	0.0015	0.0150	0.0012	0.0015	0.0150	0.0163	0.0023

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.



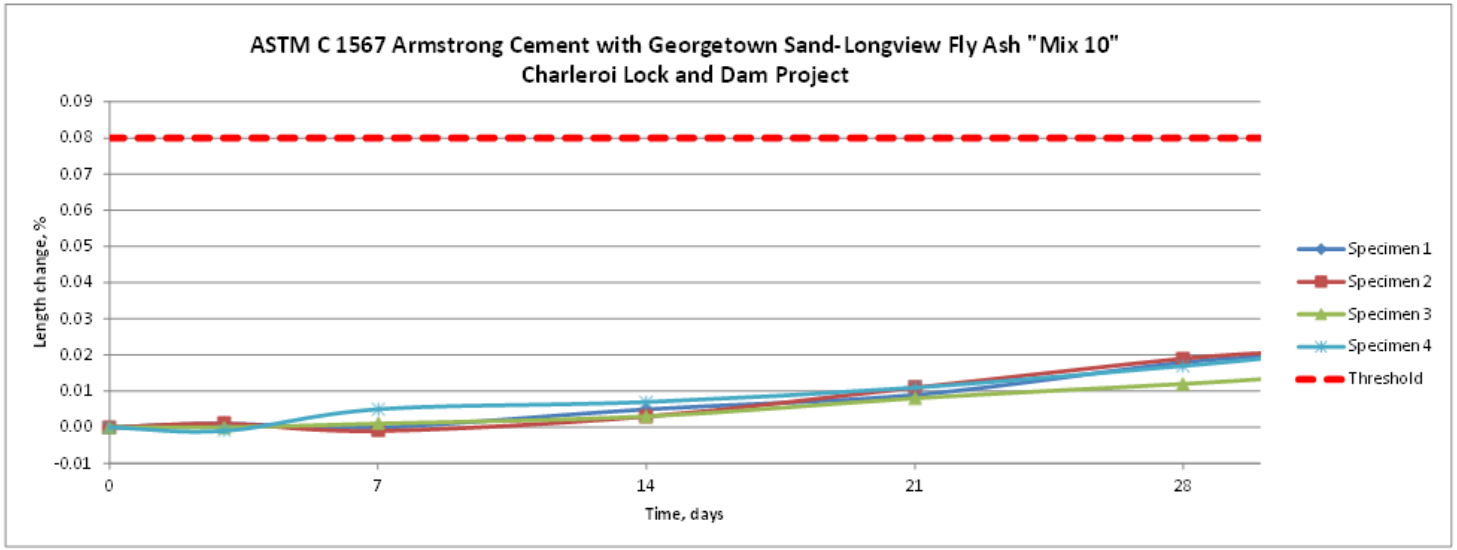
Mix:	Mix 10 with Georgetown and Ft.Martin Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	10/11/2016		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	10/13/2016		-0.0067			-0.0108			-0.0107			-0.0130				
zero read	10/14/2016	0	0.0005		0.0000	-0.0035		0.0000	-0.0033		0.0000	-0.0056		0.0000	0.0000	0.0000
	10/19/2016	5	0.0009	0.0004	0.0040	-0.0031	0.0004	0.0040	-0.0028	0.0005	0.0050	-0.0052	0.0004	0.0040	0.0043	0.0005
	10/21/2016	7	0.0010	0.0005	0.0050	-0.0029	0.0006	0.0060	-0.0028	0.0005	0.0050	-0.0051	0.0005	0.0050	0.0053	0.0005
	10/28/2016	14	0.0012	0.0007	0.0070	-0.0024	0.0011	0.0110	-0.0022	0.0011	0.0110	-0.0050	0.0006	0.0060	0.0088	0.0026
	11/4/2016	21	0.0015	0.0010	0.0100	-0.0022	0.0013	0.0130	-0.0027	0.0006	0.0060	-0.0050	0.0006	0.0060	0.0088	0.0034
	11/11/2016	28	0.0016	0.0011	0.0110	-0.0026	0.0009	0.0090	-0.0024	0.0009	0.0090	-0.0045	0.0011	0.0110	0.0100	0.0012
	11/13/2016	30	0.0018	0.0013	0.0130	-0.0024	0.0011	0.0110	-0.0021	0.0012	0.0120	-0.0040	0.0016	0.0160	0.0130	0.0022

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.

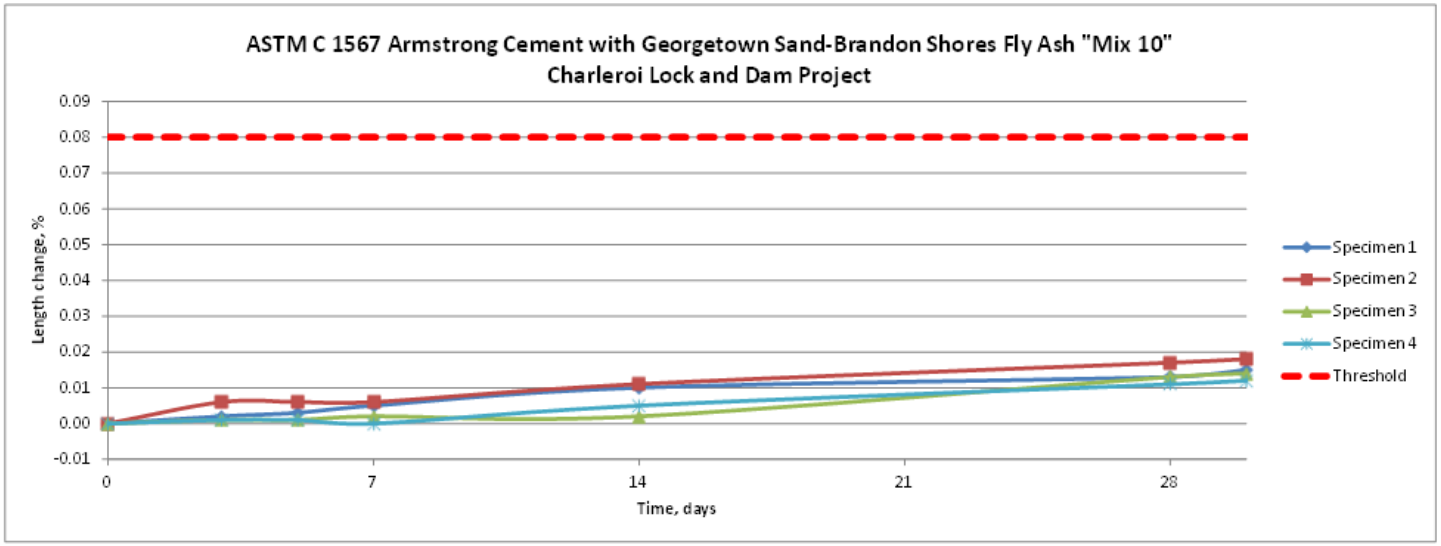


Mix:	Mix 10 with Georgetown Sand and Longview Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/MYr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	12/5/2017		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	12/7/2017		-0.0047			0.0013			-0.0054			-0.0187				
zero read	12/8/2017	0	0.0035		0.0000	0.0095		0.0000	0.0029		0.0000	-0.0105		0.0000	0.0000	0.0000
	12/11/2017	3	0.0036	0.0001	0.0010	0.0096	0.0001	0.0010	0.0029	0.0000	0.0000	-0.0106	-0.0001	-0.0010	0.0003	0.0010
	12/15/2017	7	0.0035	0.0000	0.0000	0.0094	-0.0001	-0.0010	0.0030	0.0001	0.0010	-0.0100	0.0005	0.0050	0.0013	0.0026
	12/22/2017	14	0.0040	0.0005	0.0050	0.0098	0.0003	0.0030	0.0032	0.0003	0.0030	-0.0098	0.0007	0.0070	0.0045	0.0019
	12/29/2017	21	0.0044	0.0009	0.0090	0.0106	0.0011	0.0110	0.0037	0.0008	0.0080	-0.0094	0.0011	0.0110	0.0098	0.0015
	1/5/2018	28	0.0053	0.0018	0.0180	0.0114	0.0019	0.0190	0.0041	0.0012	0.0120	-0.0088	0.0017	0.0170	0.0165	0.0031
	1/8/2018	31	0.0055	0.0020	0.0200	0.0116	0.0021	0.0210	0.0043	0.0014	0.0140	-0.0085	0.0020	0.0200	0.0188	0.0032

Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.

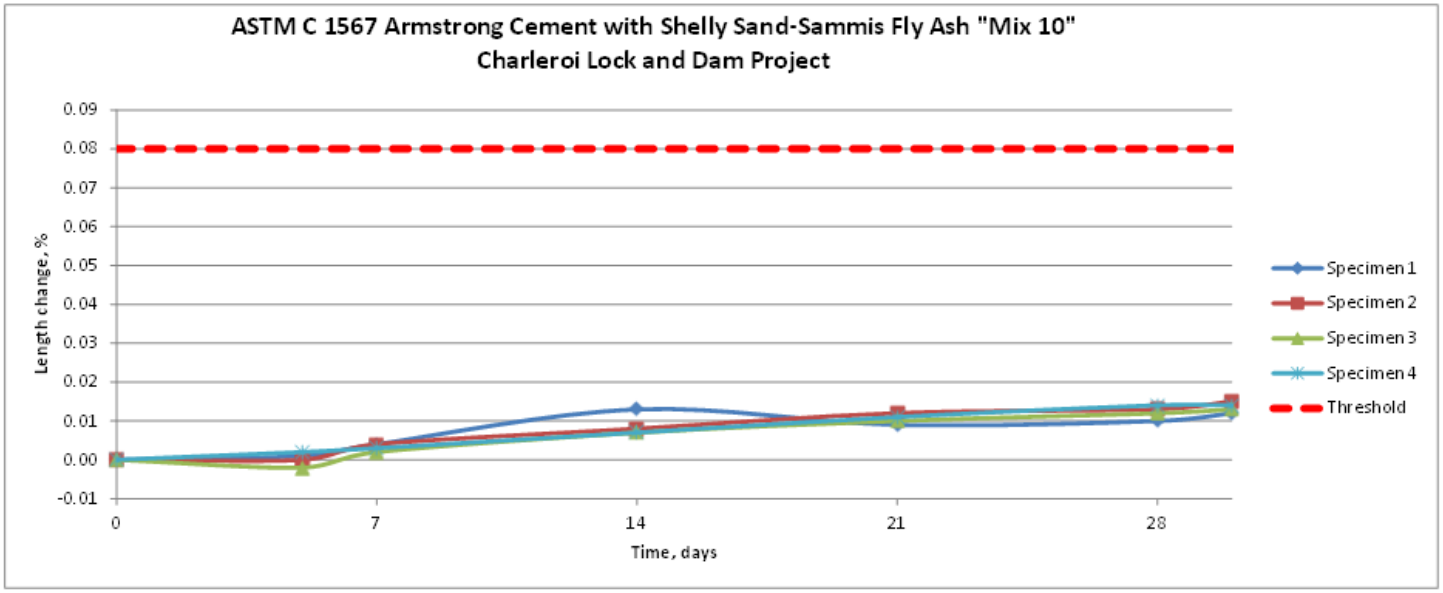


Mix:	Mix 10 with Georgetown Sand and Brandon Shores Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
			Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/MYr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	3/13/2018		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	3/15/2018		-0.0018													
zero read	3/16/2018	0	0.0050		0.0000	0.0024		0.0000	0.0033		0.0000	0.0080		0.0000	0.0000	0.0000
	3/19/2018	3	0.0052	0.0002	0.0020	0.0030	0.0006	0.0060	0.0034	0.0001	0.0010	0.0081	0.0001	0.0010	0.0025	0.0024
	3/21/2018	5	0.0053	0.0003	0.0030	0.0030	0.0006	0.0060	0.0034	0.0001	0.0010	0.0081	0.0001	0.0010	0.0028	0.0024
	3/23/2018	7	0.0055	0.0005	0.0050	0.0030	0.0006	0.0060	0.0035	0.0002	0.0020	0.0080	0.0000	0.0000	0.0033	0.0028
	3/30/2018	14	0.0060	0.0010	0.0100	0.0035	0.0011	0.0110	0.0035	0.0002	0.0020	0.0085	0.0005	0.0050	0.0070	0.0042
	4/13/2018	28	0.0063	0.0013	0.0130	0.0041	0.0017	0.0170	0.0046	0.0013	0.0130	0.0091	0.0011	0.0110	0.0135	0.0025
	4/15/2018	30	0.0065	0.0015	0.0150	0.0042	0.0018	0.0180	0.0047	0.0014	0.0140	0.0092	0.0012	0.0120	0.0148	0.0025
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.																



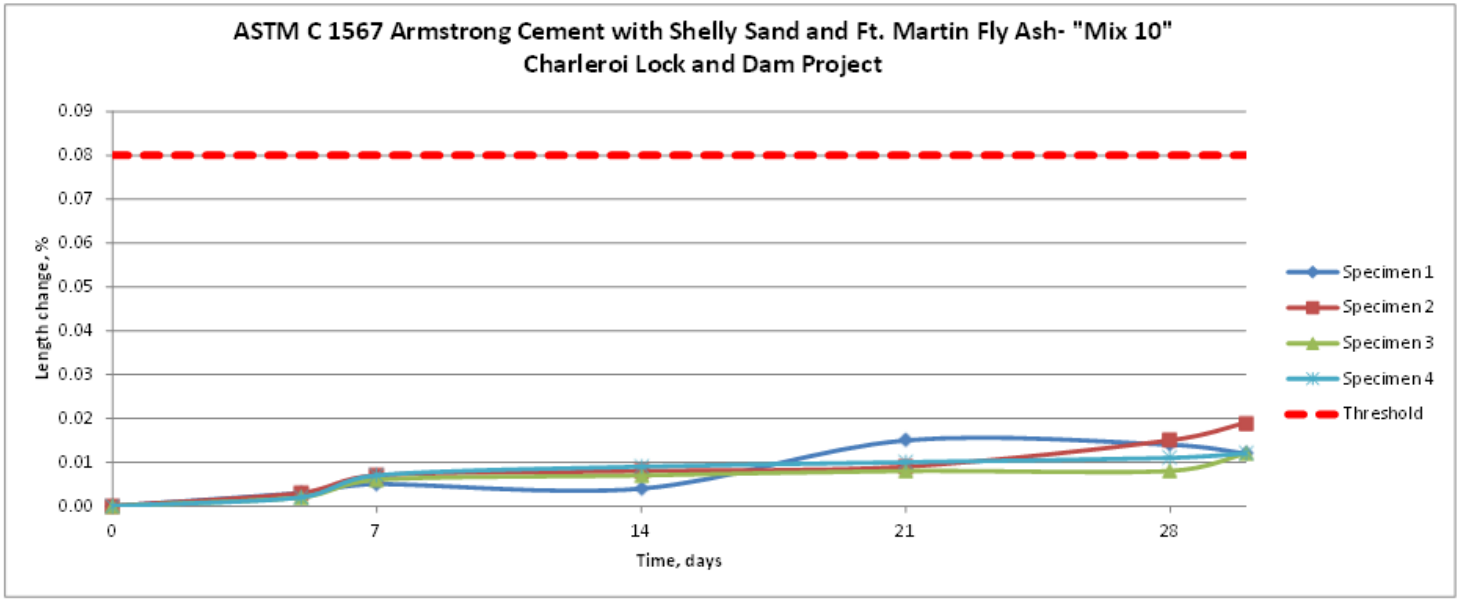
Mix:	Mix 10 with Shelly Sand and Sammis Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	10/11/2016		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	10/13/2016		-0.0060			-0.0048			-0.0083			-0.0099				
zero read	10/14/2016	0	0.0005		0.0000	0.0018		0.0000	-0.0016		0.0000	-0.0033		0.0000	0.0000	0.0000
	10/19/2016	5	0.0006	0.0001	0.0010	0.0018	0.0000	0.0000	-0.0018	-0.0002	-0.0020	-0.0031	0.0002	0.0020	0.0003	0.0017
	10/21/2016	7	0.0009	0.0004	0.0040	0.0022	0.0004	0.0040	-0.0014	0.0002	0.0020	-0.0030	0.0003	0.0030	0.0033	0.0010
	10/28/2016	14	0.0018	0.0013	0.0130	0.0026	0.0008	0.0080	-0.0009	0.0007	0.0070	-0.0026	0.0007	0.0070	0.0088	0.0029
	11/4/2016	21	0.0014	0.0009	0.0090	0.0030	0.0012	0.0120	-0.0006	0.0010	0.0100	-0.0022	0.0011	0.0110	0.0105	0.0013
	11/11/2016	28	0.0015	0.0010	0.0100	0.0031	0.0013	0.0130	-0.0004	0.0012	0.0120	-0.0019	0.0014	0.0140	0.0123	0.0017
	11/13/2016	30	0.0017	0.0012	0.0120	0.0033	0.0015	0.0150	-0.0003	0.0013	0.0130	-0.0019	0.0014	0.0140	0.0135	0.0013

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.



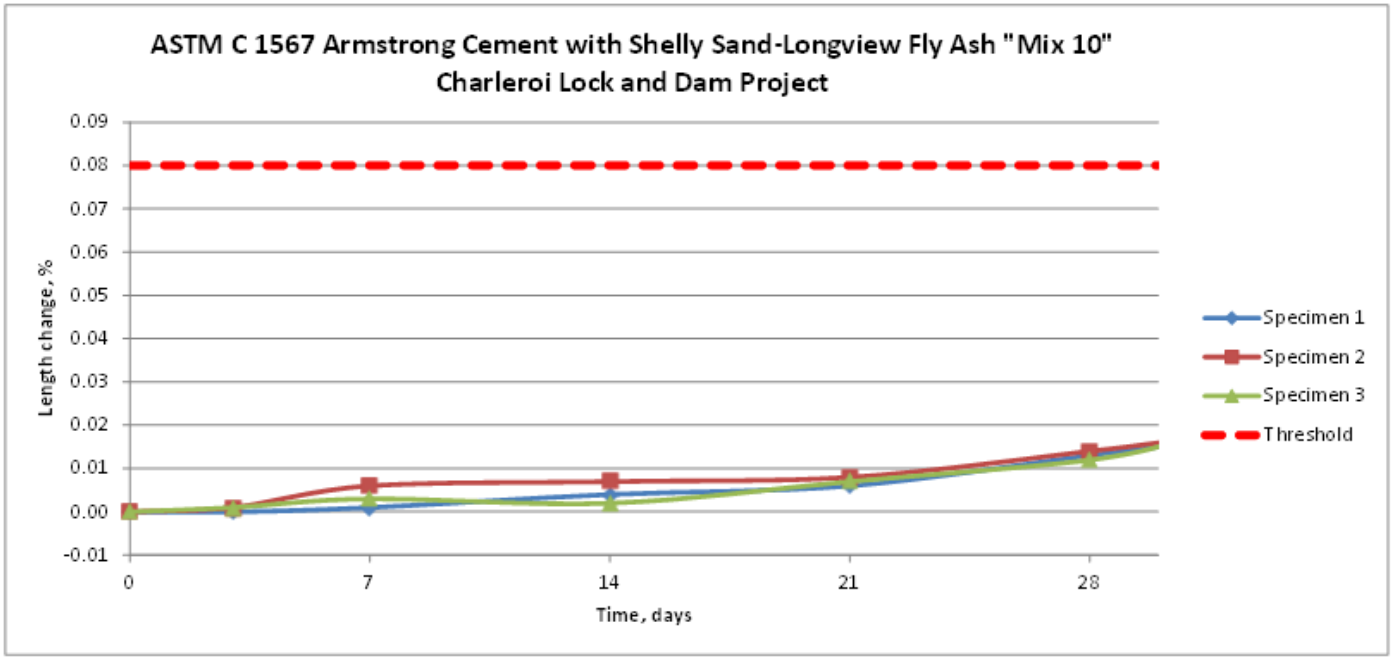
Mix:	Mix 10 with Shelly Sand and Ft. Martin Fly Ash															
Potential Alkali Reactivity of Aggregates, ASTM C 1567																
	Date		Specimen 1			Specimen 2			Specimen 3			Specimen 4			Average	Standard
Mixture		Age*	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
ID	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	10/11/2016		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial	10/13/2016		-0.0156			-0.0021			-0.0174			-0.0065				
zero read	10/14/2016	0	-0.0093		0.0000	0.0041		0.0000	-0.0112		0.0000	-0.0003		0.0000	0.0000	0.0000
	10/19/2016	5	-0.0090	0.0003	0.0030	0.0044	0.0003	0.0030	-0.0110	0.0002	0.0020	-0.0001	0.0002	0.0020	0.0025	0.0006
	10/21/2016	7	-0.0088	0.0005	0.0050	0.0048	0.0007	0.0070	-0.0106	0.0006	0.0060	0.0004	0.0007	0.0070	0.0062	0.0010
	10/28/2016	14	-0.0089	0.0004	0.0040	0.0049	0.0008	0.0080	-0.0105	0.0007	0.0070	0.0006	0.0009	0.0090	0.0070	0.0022
	11/4/2016	21	-0.0078	0.0015	0.0150	0.0050	0.0009	0.0090	-0.0104	0.0008	0.0080	0.0007	0.0010	0.0100	0.0105	0.0031
	11/11/2016	28	-0.0079	0.0014	0.0140	0.0056	0.0015	0.0150	-0.0104	0.0008	0.0080	0.0008	0.0011	0.0110	0.0120	0.0032
	11/13/2016	30	-0.0081	0.0012	0.0120	0.0060	0.0019	0.0190	-0.0100	0.0012	0.0120	0.0009	0.0012	0.0120	0.0138	0.0035

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading. Age (day) represents time of measurement after casting.

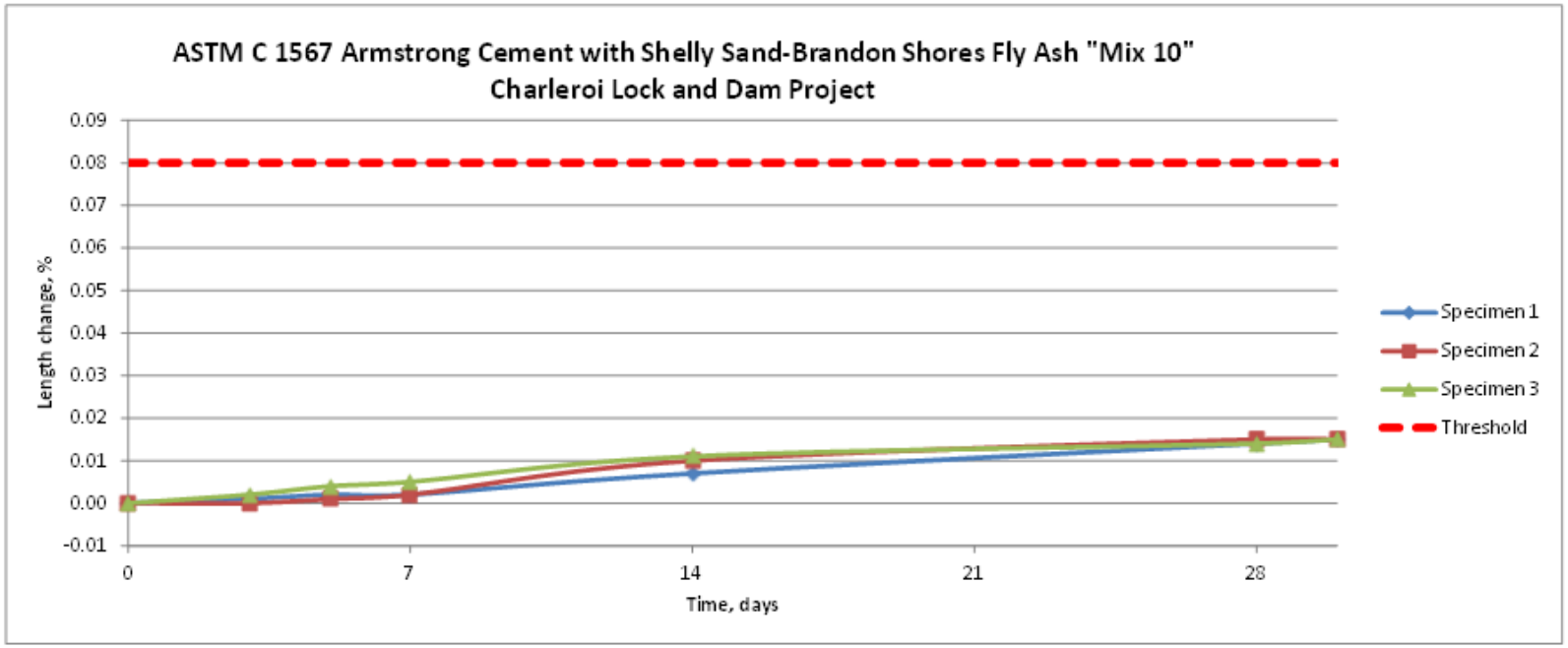


Mix:	Mix 10 with Shelly Sand and Longview Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
			Specimen 1			Specimen 2			Specimen 3			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	12/5/2017		-	-	-	-	-	-	-	-	-	-	-
Initial	12/7/2017		-0.0013			-0.0047			-0.0017				
zero read	12/8/2017	0	0.0069		0.0000	0.0032		0.0000	0.0098		0.0000	0.0000	0.0000
	12/11/2017	3	0.0069	0.0000	0.0000	0.0033	0.0001	0.0010	0.0099	0.0001	0.0010	0.0007	0.0006
	12/15/2017	7	0.0070	0.0001	0.0010	0.0038	0.0006	0.0060	0.0101	0.0003	0.0030	0.0033	0.0025
	12/22/2017	14	0.0073	0.0004	0.0040	0.0039	0.0007	0.0070	0.0100	0.0002	0.0020	0.0043	0.0025
	12/29/2017	21	0.0075	0.0006	0.0060	0.0040	0.0008	0.0080	0.0105	0.0007	0.0070	0.0070	0.0010
	1/5/2018	28	0.0082	0.0013	0.0130	0.0046	0.0014	0.0140	0.0110	0.0012	0.0120	0.0130	0.0010
	1/8/2018	31	0.0085	0.0016	0.0160	0.0049	0.0017	0.0170	0.0115	0.0017	0.0170	0.0167	0.0006

* Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.



Mix:	Mix 10 with Shelley Sand and Brandon Shores Fly Ash												
Potential Alkali Reactivity of Aggregates, ASTM C 1567													
			Specimen 1			Specimen 2			Specimen 3			Average	Standard
	Date	Age	Reading	Change	Expansion	Reading	Change	Expansion	Reading	Change	Expansion	Expansion	Deviation
	D/M/Yr	(day)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(in.)	(in.)	(%)	(%)	(%)
Mix	3/13/2018		-	-	-	-	-	-	-	-	-	-	-
Initial	3/15/2018		0.0111			0.0057			0.0036				
zero read	3/16/2018	0	0.0185		0.0000	-0.0020		0.0000	-0.0039		0.0000	0.0000	0.0000
	3/19/2018	3	0.0186	0.0001	0.0010	-0.0020	0.0000	0.0000	-0.0037	0.0002	0.0020	0.0010	0.0010
	3/21/2018	5	0.0187	0.0002	0.0020	-0.0019	0.0001	0.0010	-0.0035	0.0004	0.0040	0.0023	0.0015
	3/23/2018	7	0.0187	0.0002	0.0020	-0.0018	0.0002	0.0020	-0.0034	0.0005	0.0050	0.0030	0.0017
	3/30/2018	14	0.0192	0.0007	0.0070	-0.0010	0.0010	0.0100	-0.0028	0.0011	0.0110	0.0093	0.0021
	4/13/2018	28	0.0199	0.0014	0.0140	-0.0005	0.0015	0.0150	-0.0025	0.0014	0.0140	0.0143	0.0006
	4/15/2018	30	0.0200	0.0015	0.0150	-0.0005	0.0015	0.0150	-0.0024	0.0015	0.0150	0.0150	0.0000
Note: All expansion values use the zero reading (72 hrs). Specimen were cured 48 hours before initial reading.													



Unit Conversion Factors

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
cubic yards	0.7645549	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	meters
gallons (US liquid)	3.785412 E-03	cubic meters
inches	0.0254	meters
mils	0.0254	millimeters
ounces (US fluid)	2.957353 E-05	cubic meters
pounds (force)	4.448222	newtons
pounds (force) per square inch	6.894757	kilopascals
pounds (mass)	0.45359237	kilograms
pounds (mass) per cubic foot	16.01846	kilograms per cubic meter
quarts (US liquid)	9.463529 E-04	cubic meters
square inches	6.4516 E-04	square meters
tons (force)	8,896.443	newtons
tons (2,000 pounds, mass)	907.1847	kilograms
tons (2,000 pounds, mass) per square foot	9,764.856	kilograms per square meter
yards	0.9144	meters

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
December 2019	Final	

4. TITLE AND SUBTITLE

Laboratory Characterization of Alkali-Silica Reaction Susceptibility of Aggregates for Charleroi Lock and Dam, Monongahela River Project

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Monica A. Ramsey

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Geotechnical and Structures Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER

ERDC/GSL TR-19-52

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Corps of Engineers Pittsburgh District
Pittsburgh, PA 15222

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

Lower Monongahela River Navigation System Feasibility Study (under MIPR W81ET491842462)

14. ABSTRACT

The purpose of this study was to identify potential alkali-aggregate reactivity of local aggregates provided by the Pittsburgh District according to ASTM C1260 and to investigate the effectiveness of a combination of cementitious materials and aggregates from provided mixture designs in suppressing alkali-silica reactivity (ASR) induced expansions according to the ASTM C1567. Three ASTM C1260 tests were performed for each aggregate (Hanson, Georgetown, and Shelly). A total of 48 ASTM C1567 tests were performed from the combination of the four mix designs, four fly ash sources, and three aggregate sources. The limiting criteria for the proposed materials and mix designs was expansions less than 0.08% at 30 days of testing in accordance to the Unified Facilities Guide Specification (UFGS) Division 03 Concrete Section 03 30 00.50. Based on this specification, the tested aggregates are considered potentially reactive with 30-day mortar bar expansions of 0.1970% for Hanson, 0.1683% for Georgetown, and 0.1623% for Shelly. However, all 48 combinations of the ASTM C1567 tests passed the limiting criteria with 30-day expansions less than 0.08%. These results indicate that the constituent project materials in the proposed mix designs can effectively mitigate ASR.

15. SUBJECT TERMS

Alkali-silica reaction (ASR)
Mortar bar
Concrete
Hydraulic structures
Mitigation
Aggregate
Supplementary cementious material (SCM)
Alkali-aggregate reactions
Aggregates (Building materials)—Testing
Charleroi (Pa.)

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
Unclassified	Unclassified	Unclassified	SAR	103	